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Part Two

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A Journal of Scottish Natural History

THE SCOTTISH NATURALIST

Founded 1871

A Journal of Scottish Natural History

Editorial Committee:

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THE SCOTTISH NATURALIST

A Journal of Scottish Natural History

With which is incorporated *The Annals of Scottish Natural History* and *The Western Naturalist*

100th Year 1988

Contents
1988 - Part Two

International Society of Cryptozoology

Society for the History of Natural History

Symposium on

The Loch Ness Monster
THE SEARCH FOR NESSIE IN THE 1980s

Royal Museum of Scotland
Chambers Street, Edinburgh

25th July 1987

Edited by

J.A. Gibson
Scottish Natural History Library

and

David Heppell
Department of Natural History
National Museums of Scotland

[Proceedings - Part One]

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EDITORS

J.A. Gibson
John Hamilton
John C. Smyth
A. Rodger Waterston

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CONTENTS

1988 - Part Two

Proceedings - Part One

Preface
Mr. David Heppell 38

Symposium Programme 41

The Loch Ness Monster: Saint Columba to the Loch Ness Investigation Bureau
Mr. R.S.R. Fitter 43

The Biology of the Loch Ness Monster
Dr. R.P. Mackal 55

Public Perception of the Loch Ness Monster
Professor Henry H. Bauer 69

The Wilson Nessie Photograph: A Size Determination Based on Physical Principles
Dr. Paul H. LeBlond and Dr. Michael J. Collins 95

1988 - Part Three

Proceedings - Part Two

Loch Ness Habitats Observed by Sonar and Underwater Television
Mr. Adrian J. Shine and Mr. David S. Martin 111

A Review of Research Contributions at Loch Ness by the Academy of Applied Science
Dr. Robert H. Rines 201

Obituary: Tim Dinsdale
Mr. R.S.R. Fitter 209

Notices and Announcements

International Society of Cryptozoology 213

Society for the History of Natural History 215

PREFACE

By DAVID HEPPELL,
Department of Natural History,
National Museums of Scotland

The Loch Ness Monster, or 'Nessie' as she is popularly known, surely needs no introduction. As a symbol of Scotland, Nessie is as universal as whisky or bagpipes. Around the world her name is guaranteed to provoke argument as vigorous in attack as in defence. Serious books have been written to put her existence beyond doubt, while others equally serious have attempted to repudiate every shred of evidence. More than one museum has been dedicated to her fame. For some, belief in the Monster is an act of faith, for others their belief has been strengthened by personal experience of otherwise inexplicable sightings at Loch Ness. For a few, the search for indisputable evidence of Nessie has become a consuming passion, returning them to Scotland for season after season. But the Loch keeps its secrets well and has not yet yielded up the final proof.

Despite years of painstaking investigation and surveillance, the identity of the Loch Ness 'phenomenon' (to put it at its least) remains one of the world's great unsolved mysteries. But it has as often been a subject for mirth and hilarity as for serious consideration. Hoaxes have been perpetrated, stories have been embroidered, and 'explanations' can be bought wholesale. If this were all the story, however, Nessie's ghost would have been laid a long time ago. One important consequence of the hours of watching, filming, sampling and exploring the waters of Loch Ness is that the effects of varying conditions of light, temperature, wind and weather are now known with scientific precision. The biology, geology and hydrography of the Loch have been documented. The size, shape and speed of the local boats, birds and other inhabitants of Loch Ness have been recorded. Sonar echoes from fish and physical features have been plotted. The serious investigators are familiar with seals and otters and deer and driftwood, and if all or any of these have been responsible for reports of the Monster, they are gradually being eliminated from the puzzle. Those anomalies which remain after the layers of misunderstanding and wishful thinking have been peeled away are the key to the eventual unravelling of the scientific truth.

It is perhaps no surprise, therefore, that when the International Society of Cryptozoology chose to hold its 1987

Membership Meeting in Scotland, a whole day was allocated to a Symposium on 'The Search for Nessie in the 1980s'. The Society for the History of Natural History agreed to be a joint sponsor for the meeting, and the National Museums of Scotland, as host, decided that the Symposium should be open to any member of the public with an interest in the topic. What may be a surprise, considering the long-standing interest in Nessie, is that this was the first time that a scientific institution anywhere had provided a venue for the Nessie controversy to be aired in public.

The Symposium was dedicated to the memory of two Nessie enthusiasts who sadly had died while the meeting was being planned. Both David James, former Member of Parliament and a co-founder of the Loch Ness Investigation Bureau, and Ian Lyster, a member of the Museum's staff whose personal collection of 'Nessiana' was displayed during the meeting (and which has since been acquired by the Museum), would have been actively involved in the Symposium had they lived. The programme covered aspects of the history of the investigations at Loch Ness and of the public perception of the Monster, and the presumed biological requirements of Nessie were reviewed. Other contributions summarized the results of more than thirty years of research and fieldwork. The accompanying films and transparencies provided a very thorough compilation of the visual evidence for Nessie.

The final presentation to the Nessie Symposium, before a panel debate involving all the speakers, was by Tim Dinsdale, who reviewed his personal experiences of three decades of Nessie hunting. He also showed a remarkable selection of photographs and rare film footage of inverviews with witnesses, as well as his own classic film shot in 1960 and claimed by many to be the single most important piece of evidence for Nessie's existence.

It was a fitting tribute to Tim Dinsdale's unstinting endeavours in the cause of bringing scientific respectability to the search for the Loch Ness Monster that, immediately before his talk, an announcement was made that he had been elected an Honorary Member of the International Society of Cryptozoology. Tragically, he was not destined to enjoy this honour for long, as he died suddenly a few months later. His family have resolved to keep intact his extensive and irreplaceable archive of historical and scientifically important material, so that it can be used by future workers as a basis on which to build. It is to be hoped that a permanent home for this archive, possibly combined with that of David James, may be established within Scotland.

Parts two and three of this centenary volume of the *Scottish Naturalist* together form the Proceedings of the Symposium, and gather together the papers presented, some of which have been extensively revised for publication. That by Paul LeBlond and Michael Collins has already been published in *Cryptozoology* (Vol. 6, pp. 55-64, 1987), but the opportunity has been taken here to revise the paper and to include an additional and significant illustration which was received by the authors too late for inclusion there. The paper by Adrian Shine and David Martin has been expanded to incorporate supplementary data obtained at Loch Ness during 'Operation Deepscan' in October 1987. Sadly, the Editors had to substitute an obituary of Tim Dinsdale for the paper which would have concluded this volume, but he addressed the Symposium without notes and had prepared no manuscript by the time of his death.

Although Nessie may be regarded as the very archetype of monsters, she has been subjected to scrutiny by every device modern technology could muster to discover her true nature. No expense of time or money has been spared in her quest. It is surely then a matter for wonder that, in a rational age, when dragons and unicorns have long since been laid to rest, Nessie lives.

Symposium Programme

International Society of Cryptozoology

Society for the History of Natural History

Lecture Theatre
Royal Museum of Scotland
Chambers Street, Edinburgh

Chairman and Moderator
David Heppell
Department of Natural History
National Museums of Scotland

Saturday 25th July 1987

THE SEARCH FOR NESSIE IN THE 1980s

Morning Session

10.00 - 10.05 a.m. **Welcoming Remarks**
Robert G.W. Anderson (Director, National Museums of Scotland)

10.05 - 10.45 **The History of the Loch Ness Monster**
R.S.R. Fitter (Former Board Member, Loch Ness Investigation Bureau, and Chairman, Fauna and Flora Preservation Society)

10.45 - 11.30 **The Biology of the Loch Ness Monster**
Roy P. Mackal (Biologist, University of Chicago, and author of *The Monsters of Loch Ness*)

11.30 - 12.15 p.m. **Public Perception of the Loch Ness Monster**
Henry H. Bauer (Professor of Science Studies, Virginia Polytechnic Institute and State University, and author of *The Enigma of Loch Ness*)

12.15 - 1.00 **The Wilson Nessie Photograph: A Size Determination Based on Physical Principles**
Paul H. LeBlond (Oceanographer, University of British Columbia)

1.00 - 2.00 Lunch

Afternoon Session

2.00 - 2.40	**Recent Fieldwork by the Loch Ness and Morar Project** Adrian J. Shine (Field Leader, Loch Ness and Morar Project)
2.40 - 3.20	**A Review of Research Contributions to Date by the Academy of Applied Science at Loch Ness** Robert H. Rines (President, Academy of Applied Science)
3.20 - 3.50	Tea/Coffee
3.50 - 4.30	**Three Decades of Nessie Hunting: A Personal Odyssey** Tim Dinsdale (Author of *Loch Ness Monster, The Leviathans,* and *Project Water Horse*)
4.30 - 5.30	**Panel Debate** with all speakers, and questions from the floor

THE LOCH NESS MONSTER: SAINT COLUMBA TO THE LOCH NESS INVESTIGATION BUREAU

By R.S.R. FITTER
Chairman,
Fauna and Flora Preservation Society

Introduction

It is an unspoken assumption that a scientific paper deals with fact rather than fiction or speculation. The main problem in discussing Nessie is that it cannot be demonstrated scientifically whether the phenomenon under discussion has an independent physical basis or is the result of massive misinterpretation in human minds of real physical phenomena of various kinds. All that we can say is that a phenomenon exists which requires to be explained. What follows, therefore, may or may not be a genuine zoological problem, but since it involves many diverse and deeply held views, it is certainly a problem in human social psychology. I do not intend to enter into the multifarious controversies as to whether Nessie represents a biological or a non-biological phenomenon, and if an animal, what sort of animal. I only comment that more explanations have been advanced for the identity of Nessie than for that of Jack the Ripper or the Man in the Iron Mask, and that many of these explanations seem to be more far-fetched than the favourite one, that Nessie is a prehistoric giant reptile surviving from the age from which we now know that coelacanths have survived.

Saint Columba

We have to begin with Saint Columba, who lived in the 6th century A.D., because he is the first person recorded to have tangled with Nessie, but although a good many sightings were recorded at intervals from 1520 onwards, there is only anecdotal evidence about Nessie before the 1930s. Nevertheless, almost everybody living around Loch Ness seems always to have believed in Nessie's existence, whether or not they have been willing to say so in public.

Taxonomy

Since all serious naturalists like to classify and name their animal before proceeding to study it, it is advisable to start with a little taxonomy. In Saint Columba's day, and presumably long before that, the Water Horse or Water Kelpie

each uisge was a well-known animal inhabitant of Scottish lochs, in some of which it was called *an Beathach* or the *Beist*. Some individual water horses had their own name, usually a feminine diminutive form of the loch concerned, probably suggesting that they were regarded as a kind of water goddess. Thus there was *an Niseag* (anglicized by the local press from 1933 onwards as Nessie) in Loch Ness, *a'Mhorag* in Loch Morar and *an t'Seileag* in Loch Shiel. The great change came in April 1933, when a chance remark by Dr. Evan Barron, editor of the *Inverness Courier,* led to Nessie being renamed the Loch Ness Monster. But for this, we might well not be here today. The Loch Ness Water Horse, or even the Loch Ness Water Kelpie, does not have quite the same resonance, or the same capacity for catching the public imagination. How many people would bother with Nessie if they had not heard it called the Monster?

Finally, in 1975, in order that Nessie could if necessary be legally protected, it was given the scientific name *Nessiteras rhombopteryx* Scott & Rines 1975, based on an underwater photograph taken in 1973 and apparently representing a rhomboid or diamond-shaped fin (Scott and Rines, 1975). But like everything else about Nessie, the validity of this photograph has been challenged. If indeed, as has been alleged, the photograph on which this name was based actually represents something other than a live animal, then not only would the name be invalid, but under the International Code of Zoological Nomenclature it would become unavailable for any future genuine specimen of Nessie. Moreover, it is further claimed that the name *Nessiteras rhombopteryx* is a junior synonym of *Megalotaria longicollis* Heuvelmans 1965, a name given to a type of long-necked lake monster or sea-serpent capable of crawling on land. So if Nessie's existence as a hitherto undescribed animal is ever scientifically validated, the appropriate name would apparently be *Megalotaria longicollis*.

Explosion of Interest in the 1930s

So we come to the early 1930s and the opening of the main A82 road from Fort Augustus to Inverness, which allowed general access to a stretch of country that at the beginning of the century was still almost as remote as on the day, more than 150 years before, when Samuel Johnson rode along its shore and commented that "Lough Ness well deserves to be diligently examined". This meant that when Nessie first got wide publicity, many more people, reading the newspaper reports with interest, were able to watch out for Nessie themselves.

The explosion of interest appears to have started in April 1933, with the sighting by Mr. Alex Campbell, then a young water bailiff at Fort Augustus, which led Dr. Barron to make his famous remark, "it must be a real monster". This was soon followed by the first photograph, taken by Mr. Hugh Gray, a fitter with the British Aluminium Company at Foyers, the following November, and published in the *Daily Record* on 6th December 1933.

By the time the second famous photograph was taken, by a London gynaecologist, Lt. Colonel R.K. Wilson, early in April 1934, the Press had managed to blow Nessie up into a national celebrity. From the start, the national, as distinct from the local, newspapers treated the 'Monster' as an extension of the Silly Season, with the inevitable result that practical jokers appeared, and a circus was reported to be trying to catch the animal. This trivialization of the Nessie phenomenon by the Press has hampered serious scientific investigation ever since. On the one hand, it has proved extremely difficult, if not impossible, to persuade any of the more popular media not to ridicule such investigations. On the other hand, most professional zoologists have been reluctant to risk their names appearing in the press associated with a subject treated in this way, so they have been unwilling to investigate it seriously, or even to comment, other than dismissively, on fresh data produced by investigators. The remark attributed to the Curator of the London Zoo's Aquarium in 1934 was typical of zoological opinion at the time, and in view of the antics of the Press and various practical jokers was perhaps not surprising: "The whole business is a stunt foisted on a credulous public and only excused by a certain element of low comedy".

Start of Serious Investigations

After the spate of new observations, provoked by widespread publicity in 1933, both serious investigations and frivolous stunts began quite soon, but a trend was set when the serious investigations were not undertaken by zoologists. First in the serious field was that remarkable polymath Commander Rupert Gould, recently retired as Naval Assistant to the Hydrographer of the Royal Navy. He had already turned his encyclopaedic mind to the problem of the sea serpent, and published his researches in 1930 as *The Case for the Sea Serpent* (Gould, 1930), so it was natural that he should next tackle Nessie, and after a fortnight's personal reconnaissance during November 1933, he published *The Loch Ness Monster and*

Others in 1934 (Gould, 1934). Like other investigators, he began by thinking that Nessie must be a seal, but after talking to eye-witnesses - a precaution omitted by many Nessie sceptics - he changed his mind, and concluded that there was indeed an unknown animal, not a member of the regular fauna of Scotland, in Loch Ness. Eye-witness accounts are, of course, notoriously unreliable, but where they comprise the principal evidence of a phenomenon, they must perforce be considered by any serious investigator.

The next serious investigator was Sir Edward Mountain, Chairman of the Eagle Star Insurance Company, who had rented Beaufort Castle, Beauly, for the summer of 1934. Intrigued by the reports about Nessie, he financed a photographic expedition to the loch. Led by Captain James Fraser of Inverness, this team of twenty observers recruited from the Inverness labour exchange achieved 21 photographs and a film, and the results were shown in October 1934 to a select gathering of scientists and others at Kodak House in London. The scientists evidently did not include any with field experience of seals, for they concluded that the phenomenon they were being shown was a large seal. Throughout the history of investigations into Nessie, experts have been similarly declaring with confidence that it "must have been" something they themselves were not familiar with, but which local observers were very familiar with and had rejected.

Slackening of Interest

The debacle of the presentation of the Mountain expedition's evidence virtually removed Nessie from the national stage for more than twenty years. Sightings continued to be made and to be reported in the *Inverness Courier* and other Highland and Scottish newspapers, and occasional references emerged both in the 'Brains Trust' and other B.B.C. programmes and in the press, but by and large, despite the appearance of two additional completely reliable and most intriguing photographs, one taken in July 1951 by a crofter and woodsman, Mr. Lachlan Stuart, who lived close to the loch, and the other in July 1955 by Mr. P.A. Macnab, an Ayrshire bank manager and county councillor, the British public as a whole was scarcely conscious of Nessie's existence. This did have the incidental advantage that for a time it once more became respectable to advance rational suggestions for the Nessie phenomenon. Thus in 1951 Dr. Maurice Burton, then of the British Museum (Natural History), took a sound scientific stance by saying that he would not put the existence of a huge unknown marine animal in Loch Ness beyond the bounds of possibility, although he thought it very, very unlikely, and

speculated that it might be a giant eel. Later on, he changed his mind - more people must have changed their minds about the Nessie phenomenon, in both directions, than about any other contemporary issue, certainly any contemporary zoological issue. Scientists very properly change their minds in the face of new evidence. What is special about the Nessie phenomenon, however, is the difficulty of persuading many scientists to look at any evidence with minds unclouded by the accusations of misinterpretation and fraud which echo from the 1930s.

More Than a Legend

The scene was changed again in 1957, by the appearance of what I regard as one of the best books so far written about Nessie, *More Than a Legend,* by another surgeon, Dr. Constance Whyte (Whyte, 1957). This was the first authoritative account by someone who had lived in the neighbourhood of Loch Ness - Dr. Whyte's husband was Manager and Engineer of the Caledonian Canal - and is still the most complete and reliable compendium of eye-witnesses' statements. In fact, it presented such a convincing case for the existence in Loch Ness of an unknown animal, not a member of the known fauna of Scotland, or indeed anywhere else, that it relaunched public interest in the Nessie phenomenon. Student expeditions began to appear around the loch, and the number of references in the press, on the B.B.C., and on the newly launched independent television, considerably increased, as did the number of qualified zoologists admitting to an interest in the problem. What the editors of the Collins *New Naturalist* series called "recapturing the inquiring spirit of the old naturalists" began at last to be applied to the most intriguing remaining mystery about the wildlife of the British Isles.

The Dinsdale Film

The year 1960 proved to be a key one in this revived interest. On 23rd April Mr. Tim Dinsdale, an aeronautical engineer, took the best known film of Nessie, although there are still those who claim that he filmed a speedboat. On 27th June the Oxford and Cambridge Expedition, led by the late Dr. Peter Baker, subsequently a professor of zoology, started its observations. In the same month (see later) there began the chain of events which led to the foundation of the Loch Ness Investigation Bureau. Moreover, on 7th August, by an extraordinary coincidence, a sighting was vouched for by two independent parties, the Lowrie family in a yacht with a very close view, and Mr. Torquil Macleod and some friends on shore.

Dr. Denys Tucker

But alongside these hopeful events there was a further setback to the cause of rigorous scientific inquiry. One of the few senior zoologists who had been prepared to say openly that he thought there might be an unknown animal in Loch Ness was the Canadian ichthyologist and world authority on eels, Dr. Denys Tucker, who had been a Principal Scientific Officer at the British Museum (Natural History) for eleven years. His eel research had led him to take an interest in the problem, for the possibility that Nessie was a giant eel had been one of the more plausible explanations of the phenomenon. As a result, Dr. Tucker had lectured to many university and other audiences, and had encouraged the Oxford and Cambridge team to go and investigate the phenomenon at first hand. His dismissal by the Museum in June 1960 inevitably led many people to suppose that his known interest in Nessie played a contributory part. Whether or not this was actually so, many museum and other professional zoologists once more shrank from being associated publicly with any investigation of, or overt interest in, what might have been thought to be a legitimate field of inquiry for aquatic zoologists. So the long shadow of the Press antics of the 1930s appeared once again to have hampered the full and public scientific investigation of the Nessie phenomenon, just when it could have been most fruitful.

Revival of Interest

At this point I must interject a personal note. My own interest in Nessie was first aroused by reading a pamphlet entitled *The Loch Ness Monster,* written anonymously by Dr. Constance Whyte and reprinted from the *King's College Hospital Gazette* of 1950 (Anon., 1950). I then read *More Than a Legend,* and by 1960 was in touch with both Denys Tucker and (Sir) Peter Scott about the problem. During the General Assembly of the International Union for the Conservation of Nature, held in Poland in June 1960, I can remember discussing the subject with Peter Scott, who was a fellow delegate, in a tramcar in Warsaw on our way from the conference room to our hotel. We agreed on the need for a proper scientific investigation, and as a result of an introduction from Peter Scott, soon afterwards I found myself having lunch with the late David James in my club in London. Being a Scotsman himself, David James was quickly enthused with the idea of doing something to solve this Scottish mystery, and as a Member of Parliament he had ways and means of helping to do this which were not open to the rest of us. From these two conversations arose the Loch Ness Investigation Bureau.

The First Scientific Panel

After discussions among Peter Scott, David James and myself in the autumn, we agreed to assemble a small but distinguished scientific panel to assess all recent evidence, including sightings, photographs and sonar recordings. Peter Scott chaired a preliminary meeting in the House of Commons on 19th October 1960, when we selected the evidence to be presented to the panel. I acted as secretary, and those present included Tim Dinsdale, Torquil Macleod, Denys Tucker and Constance Whyte. It took some time to bring everybody together, so the panel itself did not finally assemble until 12th April 1961, in the rooms of the Linnean Society of London at Burlington House. Besides Peter Scott in the Chair and myself as Honorary Secretary, those present were Sir Alister Hardy and Professor Carl Pantin, Professors of Zoology at Oxford and Cambridge respectively, Dr. G.V.T. Mathews, Scientific Director of the Wildfowl Trust, and Dr. Desmond Morris and Dr. H.G. Vevers, the Curators of Mammals and of the Aquarium at the Zoological Society of London.

The evidence heard or viewed by the panel included: photographs and eye-witness accounts by both parties to the sighting on 7th August 1960 - Torquil Macleod (who sadly died only a month later) and the Lowrie family; the 1955 Macnab photograph; a sighting by the Revd. W.L. Dobb and his family on 13th August 1960; and Tim Dinsdale's film. In addition, Dr. Peter Baker exhibited echo traces from Loch Ness, which appeared to show: fish in shallow water, probably Salmon *Salmo salar* and Trout *Salmo trutta;* fish in deep water, probably Charr *Salvelinus alpinus*; objects which moved up and down; and objects between three and seven feet long, which were deeper than Charr, mostly below 50 feet. The objects in this last group were too small to account for the large objects reported from the surface of the loch, yet did not correspond to any animals known to inhabit the loch.

After considering the evidence the panel concluded that all the witnesses were clearly honest, and that there was *prima facie* evidence of something in the loch which could not be explained except as a large unknown animal. On the other hand there appeared to be insuperable difficulties in attempting to allocate such an animal to any of the principal known categories of aquatic animals, present-day or prehistoric. An attempt would be made to secure funding for further investigation. Of course, all this had to remain confidential, in order to protect panel members from the attentions of what is now called the media.

The Loch Ness Investigation Bureau

By July 1961, David James, Peter Scott and I were actively discussing the establishment of a body that would be able to pursue the necessary investigations in Loch Ness more systematically than we were able to do as individuals. The name of this body, the Bureau for Investigating the Loch Ness Phenomena, or, as it became more generally known, the Loch Ness Investigation Bureau, was deliberately chosen to deter any interpretation of its activities as other than seriously scientific and fact-gathering, and certainly not seeking publicity.

At a meeting held at the House of Commons at the beginning of December 1961, we finally agreed to set up the Bureau. Early in 1962 it was registered as a company limited by guarantee, with four directors, Peter Scott, David James, Constance Whyte and myself. The first meeting of the board of directors on 31st March was a very low-key affair, with David James and Constance Whyte meeting at David's Sussex home in Wivelsfield Green, to perform such formalities as appointing a secretary and nominating a registered address.

At this point I should make it clear that although all the directors naturally bore collective responsibility, the heat of the day was throughout borne by David James. Every successful organization needs one man to make it tick. For the L.N.I.B. David James was that man. He it was, for instance, who soon recruited Norman Collins, Deputy Chairman of the television company A.T.V. and soon to become a director of the Bureau, who provided the essential initial finance - one could do a lot with £500 in those days! It was David James, too, who later recruited to our numbers Professor Roy Mackal, who will be addressing this conference later today.

While the Bureau was slowly getting itself off the ground, others were already actively seeking a solution of the mystery. Supported by the *Observer,* the late Colonel H.G. Hasler, the well known yachtsman, carried out a preliminary reconnaissance of Loch Ness in September and October 1961, prior to his main yacht-borne expedition in June and July 1962, which overlapped another one led by the Cambridge zoologist Dr. Peter Baker. At the same time, Tim Dinsdale was continuing his annual survey visits to the loch, and Peter Scott made a reconnaissance by glider. None of these expeditions was able to advance significantly our knowledge of Nessie's identity.

Meanwhile the L.N.I.B. was devising an enquiry form, which people who made sightings would be invited to fill in, so that not only would valuable information be preserved, but some

attempt could be made to analyse it. The Bureau also organized a small study conference at the House of Commons on 23rd August, to discuss the results of Peter Baker's expedition.

Achnahannet

October 1962 also saw the beginning of David James's annual expeditions to Achnahannet, situated on the west shore of the loch a little south of Drumnadrochit; these expeditions continued until the end of the next decade, and in later years lasted for most of the summer. This represented a major effort, organized and run by David James personally, and not directly an activity of the Bureau. It was, however, partly funded by a grant to the Bureau of $30,000 from the Field Enterprises Educational Corporation of Chicago, and £1000 from the Highlands and Islands Development Board, the latter in recognition of the importance of the Nessie 'industry' to Highland tourism.

During the Achnahannet expeditions much photographic equipment was mobilized, many volunteers became highly skilled observers, and many remarkable observations were made, both by the human eye and by the cameras. Indeed, those who participated in these expeditions, and in the annual winter reunions in London, felt that they belonged to a rather special club. One of the Bureau's most important activities was the annual assessment of the year's observations and photographs from the loch, including often not just those from Achnahannet, but also from Tim Dinsdale and other observers, some of them simply members of the public who happened to be in the right place at the right time.

J.A.R.I.C. Report

Perhaps the single most important achievement of the Bureau, however, facilitated by David James's excellent contacts in official circles, was to secure a report on Tim Dinsdale's 1960 film from the Joint Air Reconnaissance Intelligence Centre (U.K.) (J.A.R.I.C.), which is, of course, an organization highly professional in photographic interpretation. The report was sent to David James on 7th February 1966 by Lord Shackleton, at that time Minister of Defence for the Royal Air Force. The J.A.R.I.C. rejected the idea that the moving object in this film was a boat, either on the surface or submarine, and concluded that "it probably is an animate object". This is the nearest to a scientific validation of the existence of Nessie that has ever been made, and even this is qualified by "probably", on the basis that if it is not inanimate it must be alive.

Need for a Permanent Loch Ness Archive

It would be tedious to enter into all the concerns of the Bureau directors during the next ten years. We were constantly receiving reports of sightings not only in Loch Ness, but also in other Scottish and Irish lochs and from freshwater lakes all over the northern hemisphere, from Iceland to Soviet Asia. As far as I know, this material has not yet been properly analysed, but if, as I hope, a permanent Loch Ness archive to hold the papers of David James and the L.N.I.B., plus relevant material from all other sources, can be set up, most suitably somewhere in Scotland and hopefully here in the Royal Museum of Scotland, this will be an important task for some future research worker. Another subject under constant discussion in the Bureau was the question of suitable equipment for recording the sights and sounds of Loch Ness, but since there is nothing so boring as out-of-date technology, I will not enter into this aspect.

The 1975 House of Commons Meeting

One important activity of the Bureau, however, must be discussed, and that is the meeting held in the House of Commons under the auspices of the All Party Conservation Committee, with Lord Craigton in the chair, on 10th December 1975, to discuss the photographs and other results of that year's Rines expedition. The Rines expeditions began in 1971, but I do not intend to discuss them, since Dr. Rines is here in person to tell you about them later in this conference. The first thing to note is why the meeting was held in the House of Commons at all. This was because the House of Commons was the only place where the meeting could be held without the unwelcome attentions of the media. Interest had been rekindled by a leak during the printing and publication of the revised paperback edition of Nicholas Witchell's book, *The Loch Ness Story* (1975), the new last chapter of which contained, by agreement with Dr. Rines, an account of his 1975 photographs. In the end, the whole of this chapter was pirated by a Scottish Sunday newspaper.

The original plan was to hold a scientific symposium in Edinburgh, but when the various academic institutions involved found themselves besieged by the media, they withdrew their sponsorship, and an attempt to relocate the meeting in London also failed. I was personally concerned with making arrangements for the London meeting place, and came to the conclusion that the Press could only have learned about the venue, either by having a remarkable number of moles or through some kind of telephone tapping.

At the meeting eventually held in the House of Commons the main speakers were Dr. Robert Rines, of the Academy of Applied Science in Boston, Massachusetts, together with his collaborators, including Dr. Harold Edgerton of Massachusetts Institute of Technology, and Mr. Charles Wyckoff of Applied Photo Sciences Inc. Other speakers, besides several directors of the Bureau, included Dr. George R. Zug, Curator of Reptiles and Amphibians at the United States National Museum in Washington, and Dr. C. McGowan of the Royal Ontario Museum, Toronto. At the end a number of scientists and others were able to ask questions, but since what had been intended to take a day and a half in Edinburgh was eventually compressed into three hours in London, inevitably the time for discussion was too short for any conclusions to be drawn. Once again, excessive media interest had frustrated serious scientific investigation of the Nessie phenomenon.

Conclusions

In many ways this was the swan song of the Loch Ness Investigation Bureau, which was wound up about a year later. At the end of the day it has to be admitted that, with the exception of the J.A.R.I.C. report on the Dinsdale film, neither the activities at Achnahannet nor the work of the Bureau itself made any substantial advance towards answering the key question, the identification of Nessie. Indeed one must draw attention to the notable fact that, again with the exception of the Dinsdale film, the bulk of the most convincing evidence for Nessie's existence has come from people who were not looking for it. One might almost conclude that taking part in an expedition to find Nessie militates against seeing the phenomenon which is under study. There is certainly a real mystery here. Why did fifteen years or so of fairly intensive investigation by the Bureau and the Achnahannet expeditions produce conclusive evidence neither for nor against the idea that the Nessie phenomenon represented an unknown living animal in Loch Ness? For that matter neither have the continuing investigations during the past ten years, both in Loch Ness and in other Scottish lochs, produced any such evidence one way or the other. We are faced with a set of observations which appear to defy scientific proof of being either animate or inanimate. This is the conundrum which still confronts us, 54 years after Nessie first burst on to the national stage.

Acknowledgements

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THE BIOLOGY OF THE LOCH NESS MONSTER

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The Loch Ness phenomena have provided a challenge to countless human beings for over fifty years. Both amateurs and professionals have tried their hand at proposing a compelling hypothesis which would explain the nature of the popularly dubbed 'Loch Ness Monster'. It should be stated at once that, to date, no completely satisfactory explanation exists. Perhaps we should not be surprised at this state of affairs, and should certainly not be discouraged in our efforts to solve the problem; most, if not all, would agree that a problem does exist (Guynn, Downing and Askew, 1985).

The difficulty arises because the thing referred to as the 'Loch Ness Monster' is a collection of phenomena rather than a single phenomenon. Research and study have identified some of the artefacts included in the Loch Ness Monster mix, which have frustrated students in the past. There is neither the time nor the space here to review all of these aspects, nor can the zoological factors be treated comprehensively. Rather, consideration will be given to possible animate explanations of the Loch Ness Monster data, which appear to be the most probable and potentially the most viable. The scope of proposed solutions to this mystery is indeed great, including many kinds of animal types, as well as a wide range of inanimate objects and processes. Representatives of almost every phylum of the animal kingdom have been proposed as the Monster at one time or another. As early as 1934, Lieutenant Commander Rupert T. Gould published a list of animals which might be the Loch Ness Monster. Gould listed: "Plesiosaurus, or other Jurassic creature, Tortoise, *Sunfish, *Ray, Catfish, Salamander, Turtle, *Shark, Eel, Ribbon-fish, Beluga, or any other species of small whale, Sturgeon, *Squid, Crocodile, Seal - also walrus, sea-lion, sea-leopard or Sea-elephant" (Gould, 1934). Gould excluded the asterisked candidates because of their known inability to survive in fresh water. This assumption is basically sound, although there is evidence that in the case of sharks, certain species have adapted to fresh water.

A comparative evaluation will be made of most of the proposed candidates, emphasizing those which appear to fit the data best. It could be that we are dealing with an entirely new type of animal; yet it is reasonable to suppose that if this is

the case, then it would fall into one of the major zoological categories. In decreasing order of probability, these are:

1. Mammalia
2. Reptilia
3. Pisces
4. Selachii
5. Amphibia
6. Cephalopoda
7. Gastropoda and other Invertebrata

The basis for this ordering will become apparent as we proceed.

MORPHOLOGY

Size

The size of the creatures in Loch Ness has been much debated, particularly outsize claims of more than 15 metres (50 feet). We do have some objective, if not precise, estimates of size, which cluster around 6-7m (20-25ft) in overall length, with weight of perhaps 1,000kg (2,200lb) or more depending on the axial ratio of the body configuration. This average figure is not meant to exclude a range of sizes, depending on age and development, from say one metre (3ft) to 15m (45-50ft).

In the case of mammals, we need only consider the aquatic forms, Cetacea, Pinnipedia, Sirenia, and *Lutra*. Cetaceans, both fossil and living forms, easily satisfy size requirements. Most pinnipeds and sirenians definitely fall short of the mark, but the largest known pinniped, the Elephant Seal *Mirounga leonina*, and the largest sirenian, Steller's Sea Cow *Rhytina stelleri*, now supposedly extinct, might qualify.

Otters (*Lutra* spp.) have been proposed; however, even the largest known otter, *Pteronura brasiliensis*, the giant South American species, with average length of 1.5m up to 2m (5-7ft) falls far short; lengths of 6m (20ft) have been reported, but never verified. Even the large aquatic Pliocene otter, *Semantor*, was not large enough.

Among the reptiles, the plesiosaurs and pliosaurs are the only forms under consideration; in both orders, some species were large enough.

Among the bony fishes (Pisces), only eels require serious consideration. No known eels are large enough, although giant marine eels have been reported, but not verified. The giant 2m (6ft) supposed leptocephalus (eel larva) caught during 1930 by a Danish expedition off the coast of South Africa turned out to be the larva of a notacanthiform fish (Spiny Eel) rather than

the larva of a hypothetical 30m (100ft) eel. It is true that among the bony fishes there are some very large forms: the giant Sturgeons *Acipenser* sp. in the Volga River and the Black and Caspian Seas reach lengths of 9m (28ft) and weigh 1,400kg (2,800 lb), and among the cartilaginous fishes (Selachii) we find several sharks of more than adequate size.

With amphibians, size is a serious problem, since the largest living species *Megalobatrachus* reaches a length of only 2m (5½ft) and fossil forms such as *Eogyrinus*, a giant salamander, reached a maximum of 5m (15ft).

Among the invertebrates only cephalopods, such as Giant Squids *Architeuthis* spp. and possibly gigantic octopuses, are large enough. Gigantic sea slugs have been suggested, but none approaches the size required.

Head-Neck

Descriptions run the gamut from short crocodile-like to long giraffe-like, with adjectives such as horse-like, sheep-like or pole-like often applied. The observed length falls most often between two-thirds to two metres (2-7ft), tapering with very little differentiation visible between the head and neck proper, thus indicating a smallish head relative to the post-cranial region. The head-neck plus body are often described as eel-like or snake-like, along with descriptions which suggest a body thickening at the base of the neck. Perhaps not surprisingly, no single known animal fits these descriptions exactly.

The elongated head-neck configuration is perfectly compatible with plesiosaurs, which had moderately long necks, but not with the elasmosaurs with their extremely long neck regions. Some species of pinnipeds begin to approach the described configuration, but would require additional neck stretching. The fused head-neck regions of modern cetaceans and sirenians exclude these types, nor do fossil sirenians display helpful features.

In the case of primitive cetaceans, however, the situation is more favourable. The archaeocetes (Slijper, 1958) are of particular interest, although the fossil record is exceptionally meagre. These animals are derived from creodont or condylarth terrestrial ancestors evolving two main lines: firstly the elongated snake-like Basilosauridae, and a second line evolving a configuration similar to modern cetaceans, i.e. Dorundontidae. The most snake-like Basilosauridae, such as *Zeuglodon cetoides*, possessed a neck region in which cervical

vertebrae were not shortened or fused as in modern whales.

My choice for a mammalian form would be an evolved form of archaeocete with a head-neck region longer than any known fossil form. The animals would have had about 20 million years to evolve a head-neck region completely compatible with the elongated Loch Ness descriptions. Of course, the eel-like or snake-like descriptions are most adequately accounted for, and some body thickening in the thoracic region is not excluded.

No amphibians, living or extinct, show a tendency towards elongated necks sufficient to satisfy the Loch Ness animal descriptions. Invertebrates, including cephalopods, do not possess elongated necks, unless we wish to give serious consideration to the segmented half-metre (18in) creatures found in the fossil beds south of Chicago known as *Tullimonstrum gregarium*. Holiday (1968) strongly supported the idea that a gigantic version of this creature might be the Loch Ness Monster.

Fish in general are ruled out, except eels and a few elongated forms, such as *Chlamydoselachus* (Frilled Shark), which would fit the snake-like descriptions but show little or no tendencies towards long necks and a somewhat thickened body in the thoracic region.

Appendages

Appendages are important diagnostic characteristics, as we try to determine what kinds of unknown animals we may be dealing with. In the case of Loch Ness, the matter of appendages is of special value, because we have some fairly decent photographic evidence (the Rines photographs) and, for me, my own observation of the distal tip of the left pectoral appendage. This observation predates the Rines photographs and is completely consistent with them.

The evidence for one pair of pectoral flipper-like organs is therefore fairly well established. The evidence for pelvic appendages is much more problematical.

The evidence for appendages used as paddles comes mainly from eye-witness reports. At least, some of the data suggest that only one pair of appendages is present. The few land sighting accounts might be expected to settle the matter; unfortunately, this is not the case. For example, in August 1933 Mrs M.F. MacLennan claimed to have seen four short, thick clumsy legs with pig-like hoofs. Originally she did not report limbs, but only when pressed, over twenty-five years later, did

she 'remember' this detail (Burton, 1961); not exactly a report to inspire confidence. In January 1934 Mr. Arthur Grant claimed four appendages, but was very vague, especially about rear ones, using dashed lines on some of his drawings, which suggested to me that he was merely inferring their existence (Burton, 1961; Mackal, 1976).

In my judgement, therefore, one pair of pectoral flippers is fairly firmly established, but the question of pelvic appendages remains open.

All of the present-day aquatic mammals fit the pectoral-flippers-only pattern, and not the four-appendage condition. We must also consider more primitive evolutionary forms, which were not yet as fully adapted to an aquatic environment and still had four limbs. Plesiosaurs, of course, fit only the four-appendage configuration. In the amphibious urodeles, one encounters mostly four appendages, although there are forms with only two, or the posterior pair much reduced. Eels have only one pair of pectoral fins, except primitive ancestral types, in which pelvic fins were still present. Some species of marine eels, such as the Moray *Muraena helena*, have neither pectoral nor pelvic fins. Most invertebrates, especially molluscs such as gastropods, do not have appendages which lend themselves to identification as one or two pairs of flippers, although a few species of sea slugs have developed rounded rowing parapodia, which might be so characterized.

Integument

Apart from the size and shape of the animals, the colour and texture of the skin has often been reported, especially by observers at close range. Colour has been described as black, greyish-black, blackish-brown, reddish-brown, and "black, like the skin of an elephant". A few reports refer to a lighter ventral surface. The texture has been described as tough-looking, sometimes rough, bare i.e. not hairy, and in some cases wrinkled. No scales have been reported. Dinsdale and a few others reported dappling. Of course, distance of observation, lighting conditions, and other variables under which the observations were made, have all contributed to the variability of colour and texture descriptions.

By and large, these descriptions are all compatible with cetaceans, some pinnipeds, some amphibians, some sharks, eels, some invertebrates, and certain reptiles - particularly plesiosaurs, which had smooth skin without dermal armour. Nothing is known of plesiosaur colouration, but the colour range of modern reptiles certainly covers the descriptions. Wrinkling and mottled colouration occurs in some species of all

groups, although cetaceans, pinnipeds and sirenians do not ordinarily possess dappled colouration, such as described by Dinsdale. Out of several hundred ordinary Eels *Anguilla anguilla* collected by us at Loch Ness, two displayed mottled colouration.

Eyes

The majority of eye-witness reports make no reference to eyes, possibly because many observations are made at too great a range. Those reports which do mention eyes appear quite inconsistent, ranging from small to large and in some cases slit-like.

Animals with small eyes and eyelids would account for all observations, except those describing large conspicuous eyes. Sirenians, pinnipeds, cetaceans, and plesiosaurs would fit the bill. In plesiosaurs the eyes were small in the smaller headed forms, which concern us most. Some reptiles have moving eyelids (nictitating membranes) but others do not, so we need not exclude plesiosaurs on that basis. Many amphibians, especially the urodeles, show a considerable range of eye development, including small eyes, large eyes, slit-like eyes or no eyes at all. In some forms the eyes are large in larval forms, but are reduced in size as development proceeds. Some have functional nictitating membranes, but others do not.

The eyes of eels range from slightly oval to round, and are also capable of considerable pupil movement with contractile irises in response to increased light. All sharks have contractile irises, with ability to contract into a horizontal or vertical slit.

In some molluscs there is quite a range of eye forms, but in the case of sea slugs the visual organs are not compatible with our data.

ENVIRONMENT

Temperature

The temperature of the loch is relatively constant below the thermocline at approximately $5\frac{1}{2}$°C (42°F), never freezing at the surface. This low temperature severely restricts the kinds of animals which might be expected to be found there.

Sirenians are restricted to tropical waters, except *Rhytina stelleri* which was at home among the ice floes. Of course, cetaceans and pinnipeds would find the temperature of Loch Ness most comfortable.

In the case of the plesiosaur hypothesis, however, we encounter a most serious difficulty. These reptiles are believed to have inhabited warm seas and to have been ectotherms. Now plesiosaurs are not dinosaurs, but it should be noted that there is considerable evidence that at least some dinosaurs were warm blooded, the most important evidence for this condition being the presence of an extensive vascular (Haversian) system, similar to mammals, in the bones of some dinosaurs. If this is correct, it may be that some plesiosaurs also evolved in this direction parallel to dinosaurs, although I know of no published studies of plesiosaur fossils regarding this feature.

It should be noted that Leathery Turtles *Dermochelys coriacea* are capable of maintaining a body temperature of at least 18°C above an ambient level of 7.5°C. It remains to be determined whether they are warm blooded mainly on account of their size and thermal inertia, or whether they actively regulate their temperature, as suggested by the existence of countercurrent heat exchangers at the junction of flippers and body (Mrosovsky, 1987).

In contrast to reptiles, amphibians have adapted to a very wide range of environmental temperatures. This is true in spite of the fact that amphibians, like reptiles, are ectotherms. However, they have achieved this adaptation by making a variety of sacrifices, including a reduction of the mode and tempo of life which does not nearly approach what is required to satisfy the Loch Ness criteria.

We need not dwell on the viability of fish, and eels in particular, since they are found in abundance in Loch Ness, and are obviously well adapted to the environment. Many invertebrates, particularly molluscs, would be comfortable at the temperature of the water in Loch Ness.

Fresh Water

The freshwater conditions in Loch Ness restrict possible animal life to those types which are in osmotic equilibrium with low salinity, or have an impervious integument.

In all three major groups of marine mammals, there are some species which are at home in fresh water, although these forms are the exceptions. Many plesiosaurs apparently were at home in either fresh water or salt water, or in both. The remains of many forms have been found in what appear to have been freshwater environments, particularly estuaries and rivers.

Amphibians, for all practical purposes, are confined to fresh water, which would exclude them from any migratory movements from fresh water to the sea or vice versa.

Anguilla, ordinary Eels, are catadromous fish; i.e. they are oceanic fish which leave the sea as juveniles to pass their period of growth in fresh water. Mature adults eventually return to the sea, after five to thirty years in fresh water, to spawn.

Invertebrates, especially molluscs, have many species adapted to either fresh water or salt water, but not to both. Cephalopods and sea slugs are exclusively marine, and so can be excluded on this basis.

Food Supply

Ever since the Loch Ness mystery entered public awareness, the question "What do they eat?" has been debated. If we knew nothing else about the Loch Ness animals except their distribution, we would have to answer "fish", since this is the only adequate food supply which could sustain even a few animals with the size, mode and tempo of life attributed to the Loch Ness creatures. Other food supplies have been suggested, such as the organic deposits at the bottom of Loch Ness, but without exception such suggestions are not viable.

Papers have been published as to how much 'Monster biomass' could be supported by the indigenous food supply in places like Loch Ness (Sheldon and Kerr, 1972; Scheider and Wallis, 1973). The resulting numbers include much guess work, but generally come out between 10 and 100 individuals, depending on what average bulk is assigned to the animal. In all except one or two cases, however, the migratory fish population entering Loch Ness was not included. Intimately associated with this consideration is the question of what would be a minimum self-sustaining population.

Brussard addressed this question in some detail in a paper published in *Cryptozoology* in 1986. He suggested that populations of fewer than twenty individuals would be at high risk of extinction from stochastic events, particularly environmental uncertainty, populational uncertainty, and genetic uncertainty. In general, and in the Loch Ness case in particular, the first two do not seem important in that most postulated small surviving populations are believed to exist in environments stable over long periods of time, and without major predators capable of causing catastrophic population reduction. The survival of giant Monitor Lizards *Varanus*

komodoensis as a very small population on three or four small islands in the lesser Sunda chain of Indonesia, under such conditions, is a case in point.

For cetaceans and pinnipeds, as well as plesiosaurs, fish is a perfectly suitable food supply; not, however, for sirenians, which must therefore be excluded. However, some amphibians, and certainly eels, as well as many types of molluscs, do feed on fish.

BEHAVIOUR

Locomotion

Under this heading a variety of topics must be considered.

The most important aspect is how the animals move, i.e. swim and change depth. There is objective data available for consideration, apart from anecdotal eye-witness estimates of swimming speed at the surface. There are motion picture and underwater sonar sequences, which establish this parameter of behaviour. These data establish surface movement to be from zero to 16 kilometres/hour (10 mph) and diving rates of up to 8 km/h (5 mph). Very much higher estimates of speed given by some observers are probably grossly in error, for a variety of reasons which cannot be discussed here.

Cetaceans and pinnipeds easily account for the measured speed and diving performance. The known behaviour of sirenians, however, excludes them.

In the case of plesiosaurs, we have an interesting problem. The question of locomotion, including diving, has been studied in some detail, particularly by Robinson (1975, 1977), Newman and Tarlo (1967), and Taylor (1981). The crux of the problem here is that the forms which might be capable of the required performance were the short-necked pliosaurs rather than the longer-necked plesiosaurs. In contrast, the anatomical features of plesiosaurs fit the morphological data, but not the swimming and diving data.

Taylor (1981) concluded that the plesiosaurs, with their small heads on exceedingly long necks, apparently had a most unstreamlined shape which perhaps made them too slow to pursue prey in open water. The other main group, the pliosaurs, were large carnivores, perhaps comparable to modern Killer *Orcinus orca* and Sperm Whales *Physeter catodon*, and Taylor believes they may have been open-water cruising predators.

Robinson (1975) concluded: "The short-necked pliosaurids were manoeuvrable sea-lion-like animals, while the long-necked

plesiosaurids were slower endurance swimmers like the sea turtles, and were not especially agile in their movements".

The pliosaurs also appear to have had the right configuration for the required diving performance. However, to account for such a performance, special adaptations of brain, lung, and heart functions during diving and recovery, comparable to cetaceans and pinnipeds, would have been required (Hochachka, 1981), but practically nothing is known about any such physiological adaptations.

Scott Eckert, of the University of Georgia, recently announced that a Leathery Turtle had dived to a depth of 1,200m (Eckert *et al.*, 1986). In fact, the recording device, a combination of a tiny light on a pressure-sensitive arm and a rotating film, had been pushed off the scale. Calibration allowed the 1,000m mark to be specified accurately, and by extrapolating from the relationship between depth and duration of other dives, Eckert and his colleagues estimated that the turtle had dived to a depth of 1,200m. This is deeper than the 1,140m for a Sperm Whale, and is probably a record for an air-breathing vertebrate (Mrosovsky, 1987).

Amphibians must be excluded, because of the known swimming and diving ability of present-day amphibians, and relevant information inferred from fossils.

Certain fish, particularly eels, can undoubtedly swim fast enough, from $1\frac{1}{4}$ to 19 kilometres/hour (2-30 mph). Diving, however, is a problem for all fish with closed swim bladders. Eels have open swim bladders and so can change depths rapidly without harm. At Loch Ness we rapidly pulled up eel traps containing Eels from depths of 200m (650ft); the Eels were unharmed and behaved normally.

The observed speeds also rule out molluscs, with the exception of squids, and essentially all other invertebrates.

The dorsal contours, i.e. humps, could have been discussed under morphology, but appear to be closely related to locomotion and so will be addressed here. As has often been observed, variable back contours, i.e. humps, are too often reported to be dismissed, although Dinsdale's film and many other observations describe only a solitary dorsal contour. Often it is tacitly assumed that the part displayed breaking the surface must represent the dorsal anatomy of the creature, but I should point out that this may not necessarily be the case. An elongated vertically flexible animal lends itself most easily to explaining a multi-humped configuration, including

variability of observations of one to three or four humps. It should be remembered, however, that if several animals are observed in close proximity, odd configurations may be displayed to an observer.

The upturned boat aspect filmed by Dinsdale is certainly an aspect which must be explained. To explain this feature, animals with a certain amount of vertical vertebral flexure are required, which of course excludes invertebrates, but aquatic mammals fill this requirement quite well.

Much has been made of the fact that almost all reptiles flex primarily horizontally, although one should not forget the typical pose of reptiles such as the Indian Cobra *Naja naja*. Studies of plesiosaurs with long necks indicate that this portion of the vertebral column had a degree of freedom sufficient to produce significant vertical flexure. But what about the back contour? Reconciliation with a multi-humped configuration is as difficult to explain as in the case of aquatic mammals.

It would appear that the single-humped aspect is consistent with plesiosaur anatomy and the plesiosaur type of swimming, i.e. underwater flying, rather than rowing or paddling. Anatomical studies by Robinson (1975) and Taylor (1981) suggest that both pliosaurs and plesiosaurs flew through the water; propulsive body forces were directed to the roots of the wings via an archer's bow construction of the body, which suggest back contour and vertical flexure consistent with Loch Ness single-humped configurations.

It should be noted in passing that Robinson concluded plesiosaurs could not come out on land, because of the lack of a sternum. They had instead a gastralia or ventral basket. Taylor, however, concluded that plesiosaurs could have come out on land. It is interesting that a two-humped aspect might be displayed, if the plesiosaur tail fin were also to break the surface when the back was partially out of the water. If the tail fin were a steering or propulsive organ, one would rarely see it displayed out of the water during active swimming.

If a soft, floppy continuous dorsal fin were present in any of these animals, such as in eels, or in some amphibians, a variable contour might be observed in silhouette. It has also been suggested that eels might surface turning sideways to display what would appear to be vertical flexure.

Invertebrates might readily flex vertically or horizontally as required.

Amphibious Behaviour

Perhaps the most interesting and curious aspect of the Loch Ness animals is that they have occasionally been reported on land, possible eighteen such reports in 436 years. Movement is described as clumsy and awkward.

On these grounds, one can dismiss sirenians immediately. Pinnipeds, in contrast, are too terrestrial and must come out on land to give birth. It is reasonable to suppose that the Loch Ness animals produce live births in the water. Modern cetaceans never come out on land voluntarily, and the larger forms rarely survive beachings. The Killer Whale does hunt seals in the shallows, and in the pursuit of seals can almost but not quite come completely out of the water. Some porpoises and dolphins also come into the shallows, in some of North Carolina's brackish estuaries, in pursuit of fish and even shore birds.

These animals can be trained by man to come out on to the edge of pools. Whether a primitive snake-like archeocete might be capable of excursions over land cannot be determined from the sparse fossil record. Plesiosaurs probably came out on land, but would also have to be ovoviviparous, incubating the egg in the body cavity and producing a live water birth.

Many species of amphibians have no difficulty coming out of water on to land, although one would hardly expect them to be as inefficient in movement as described. By definition, amphibians give birth or lay eggs in the water. Eels also are able to come out on to land and may with some facility traverse distances of up to 30km (20 miles), especially at night over damp grass. Many invertebrates, especially gastropods, are able to come out on to land, and many are completely terrestrial as adults; however, it is doubtful if invertebrates the size of the Loch Ness animals could function out of the water.

CONCLUSION

Based on all of the above factors, I rank the candidates in descending order of probability as follows:

1. Archeoceti: I believe that a type more advanced than *Zeuglodon cetoides* is called for, rather than a more primitive type. *Prozeuglodon* was more whale-like, comparable to the other mainline of archeocete evolution, the Dorundontidae. I suggest that the Loch Ness animals may be classified as an advanced archeocete belonging to the Basilosauridae, with a cervical

region significantly longer than was present in *Zeuglodon cetoides* (Mackal, 1980).

2. Pinnipedia: With regard to pinnipeds, I believe the best candidate would be a very large version of the Leopard Seal *Hydrurga leptonyx*, with a much greater adaptation to a fully aquatic existence.

3. Plesiosauridae: A plesiosaur which was ovoviviparous, endothermic, and with a moderately long neck such as *Cryptocleidos*, might fit the necessary requirements.

4. Anguillidae: A large, thick-bodied, long-necked eel able to turn sideways at the surface to present vertical flexure seems an unlikely creature, but would account for much of the data.

Nature may yet surprise us.

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PUBLIC PERCEPTION OF THE LOCH NESS MONSTER

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Introduction

Public perceptions are always formed indirectly. Those who see something must report their observations, and their reports must be listened to, and these reports must then be passed on, if a public perception of what occurred is to form. Now all of us select what we report - we don't tell all; and those who first hear reports again select which of them to pass on; and so the public does not come to know of a thing just because it happens or just because it exists, but because a series of choices has been made to pass information along.

In the case of something like the Loch Ness Monster, that is to say an anomalous or unexpected phenomenon, there are some characteristic flaws in the transmitting of information, as Westrum (1977, 1978, 1979, 1982) in particular has shown. Eye-witnesses are inhibited from reporting because they suspect that they will be ridiculed rather than believed; and so reports tend to be made if and when observers feel they will be listened to, rather than when their observations are actually made. In consequence, an absence of reports does not mean that something is not happening. Further, once any report is published, other observers feel encouraged to recount their own experiences, often long after the event; and so public reports tend to come in bunches, or 'flaps', even if the phenomenon itself has a more uniform distribution in time. Westrum has illustrated these effects for several anomalies, or "hidden events" as he calls them: UFOs, meteorites, sea-serpents, child abuse; and I myself have found that the literature about Loch Ness supports the same generalizations.

Selection

Those who receive reports, for instance editors of newspapers, must select what to publish; and they have some typical biases: for example, an editorial policy which takes into account what the readers of the particular paper want to read, a well-founded cynicism which recognizes the existence of hoaxers, and a not-so-well-founded faith that the appropriate scientific experts always know which phenomena can occur and which phenomena cannot.

Thus what the public learns about Nessie, say, may bear little relationship to any actual events at Loch Ness, even leaving aside inaccuracies in reporting what eye-witnesses have actually said, which has not been uncommon (Campbell, 1972: 32-33; Dinsdale, 1961: 13; Gould, 1969: 14-15; Whyte, 1961: 79). Furthermore, it is not merely information which is passed on by the newspapers (and magazines, radio, and so forth), but also their attitudes towards that information: thus a headline which reads 'ANOTHER SIGHTING AT LOCH NESS' may refer to exactly the same event as, yet convey an impression quite different from, one which reads 'SILLY SEASON OPENS AGAIN'. Editorial policy is exercised as much through the choice of how to mention something as by the choice of what to mention.

Reliability

In general, what the public learns about unusual or anomalous or controversial matters is often unreliable. Walter Lippmann (1955) put it nicely:

"When distant and unfamiliar and complex things are communicated to great masses of people, the truth suffers a considerable and often radical distortion. The complex is made over into the simple, the hypothetical into the dogmatic and the relative into an absolute".

Now the Loch Ness Monster is distant and unfamiliar to most people, and its possible existence is a complex rather than a simple issue. So we should expect to find the public view to be a distorted one; and in order to understand its origin we must look not only at what has been written, but also when, and how much, and in what vein. I have done that on the basis of a collection of writings about Nessie which I have been accumulating for a number of years with assistance from many people. Most of the literature is listed in an appendix in Bauer (1986) and a complete list is in a computer file whose description is available from the author upon request. How the literature was analysed is described in Bauer (1987), and an earlier analysis was reported in Bauer (1982).

Widespread Knowledge

Almost everyone, at least in the English-speaking world, has heard of the Loch Ness Monster. It is featured in advertisements: for Kodak, logically enough, but why for Epson computers, or for Miracle Whip mayonnaise, or for the Crown Jewellers? It appears in a colouring kit for children at Busch Gardens in Virginia, where the roller-coaster is called the Loch Ness Monster; also in a topiary at Disneyland. The Loch Ness Monster has become the very type-specimen of the water

monster: a naturalist who used to draw sea-serpents as elongated, mosasaur types (Thone, 1937) came later to picture them (Thone, 1949) as Nessie-like plesiosaurs. A distributor of scientific supplies uses the example of Nessie to describe what a plesiosaur is (Carolina Biological Supply Company, 1981). When a sea monster is reported, it is referred to as a Chinese, or New Zealand, or Swedish... *Loch Ness* Monster or Nessie.

Jocular Attitude

The attitude conveyed in these references is almost always an unserious, even a joking one: thus the *Mutual Fund Forecaster* (No.28, May 1987) mentions the "Loch Ness Option...This 'Monster' of a fund...."; or Nessie can be pictured, as in a float at the Rose Bowl Parade in California, in the colours (pink and mauve) of the sponsors (Baskin-Robbins ice cream), not in any manner which corresponds to actual reports from eye-witnesses. The implicit but quite clear message is that there is no original to which one need be faithful: Nessie is a symbol or a myth, not an actual creature. So too Nessie is featured in cartoons, and not uncommonly is connected with the tourist industry.

Now, how did this popular public perception arise? An answer can be found, I think, in the newspaper coverage given to Loch Ness during the flap of 1933-34 (Table 1). Note the peak in coverage during December and January, which is much greater than warranted by any increase in sightings. Thus in the summer of 1934 there were significantly more sightings but considerably less coverage. Quite generally, it seems that newspaper coverage fluctuates more than does the rate of sightings, and that the coverage fluctuates less in local or regional papers than in national ones (Table 2).

The *Times* had taken an open-minded stance at first, but in an editorial of 18th January 1934 dismissed the matter as without substance; and thereafter - for the subsequent half-century, in fact - references in the *Times* were very infrequent. For the rest of 1934 the *Times* carried only about one item a month; even the *New York Times* had twice as many, while the *Glasgow Herald* and the *Inverness Courier* on average had items more than once a week. From 1935 to 1937, Nessie was mentioned only once in the London *Times*, twice in the *New York Times*, but on more than twenty occasions in the *Inverness Courier* and the *Glasgow Herald*.

Early Hoaxes

Now there was quite adequate reason for the *Times* to become disbelieving in mid-January 1934. There had just been

Table 1

Frequencies of Sightings and Newspaper Items
1933-1934

		Reported Sightings*	Items in London *Times*	Items in *Glasgow Herald*
1933	May	3	-	-
	June	4	-	-
	July	2	-	-
	August	15	-	-
	September	7	-	-
	October	8	-	1
	November	7	-	2
	December	11	29	16
1934	January	7	17	15
	February	4	-	3
	March	-	1	4
	April	3	1	6
	May	4	1	9
	June	6	1	4
	July	17	1	11
	August	7	6	7
	September	1	3	5
	October	-	1	5
	November	-	2	1
	December	-	2	2

*See Bauer (1987) for provenance of these data.

Table 2

Monthly Rates of Sightings and
Items in Various Newspapers

	A	B	C	D
Sightings	6.4	9.0	3.8	1.9
Items in:				
Inverness Courier	5.0	25.0	6.0	0.5
Glasgow Herald	0.5	16.0	5.0	0.5
New York Times	-	7.0	2.0	0.05
London *Times*	-	65.0	1.0	0.03

A = May 1933 to November 1933

B = 8th December 1933 to 18th January 1934

C = Rest of 1934

D = 1935 to 1937

perpetrated two major hoaxes, one involving a supposed spoor on the shore, and another the finding of bones from a purported monster-meal, shortly after a land sighting had been reported which was in itself not easy to believe.

National and Local Papers

At any rate, it seems that the present-day public perception of Nessie still corresponds to the negative and jocular stance originally adopted by the national and international newspapers in mid-January 1934, which stance has not changed over the years. The regional and local papers, on the other hand, have continued to take a comparatively open-minded, matter-of-fact stance and to report sightings fairly steadily; but of course their influence on public perception is more limited. (A study of writings about UFOs also found that regional papers give steadier coverage than do national papers (Strentz, 1970)).

Note how conservative the editorial policies of newspapers are. With the local or regional papers, as much as with the national ones, the stance taken on Nessie has not altered in more than fifty years, during which much else in the story of Nessie *has* changed. Editorial policy, not events, determines what is published: the *Times* doesn't believe, so it doesn't mention the matter - in 1934 it did not even mention the 'Surgeon's photograph', which has become Nessie's veritable logo and which was published at the time in the *Daily Mail* and in the *New York Times*. The regional papers, on the other hand, perhaps because they cannot bring themselves to dismiss entirely the testimony of known local people, continue to publish matter-of-fact reports. Whether one stance is more warranted than the other is not here the point, which is simply that it is editorial policy which is decisive and that this is not necessarily the same as the actual events. An illustration from the United States is shown in Table 3: reports about Loch Ness are compared in a national, a regional, and a local newspaper over a period of nine years, during which there were reports on fourteen occasions; on only one of those occasions did all three papers carry the report, and on only one other occasion did as many as two of the papers feature the same story! That editorial policy can remain fixed for a very long time indeed is also illustrated by the *Oban Times,* which refused up into the 1970s to carry any mention of sea monsters because the paper had been hoaxed on that issue in 1877! (Campbell, 1972: 102).

Distortions

Coverage is distorted not only by editorial policy, but

Table 3

Coverage of Loch Ness
in National, Regional, and Local Newspapers

	Times (New York)	*Courier-Journal* (Louisville KY)	*Herald-Leader* (Lexington KY)
1967	-----	12 March (AP, general)	-----
	-----	7 May (UP, re LNIB)	-----
	14 May (Chicago, re LNIB)	-----	-----
1968	-----	4 February (UPI, re LNIB)	-----
1969	-----	5 October (*L.A.Times*, re LNIB)	-----
1970	24 September (UPI, re Ulrich)	-----	-----
	-----	-----	24 November (UPI, re Morar)
1971	15 April (re LNIB)	-----	-----
1972	16 January (general)	-----	-----
	2 April (carcase hoax)	-----	-----
	-----	7 May (*L.A.Times*, Dinsdale)	-----
	3 November (AAS photos)	-----	3 November (AAS photos)
	-----	-----	3 December (AP, general)
1975 November to 1976 January, about cancelled symposium:	6 items	5 items	3 items

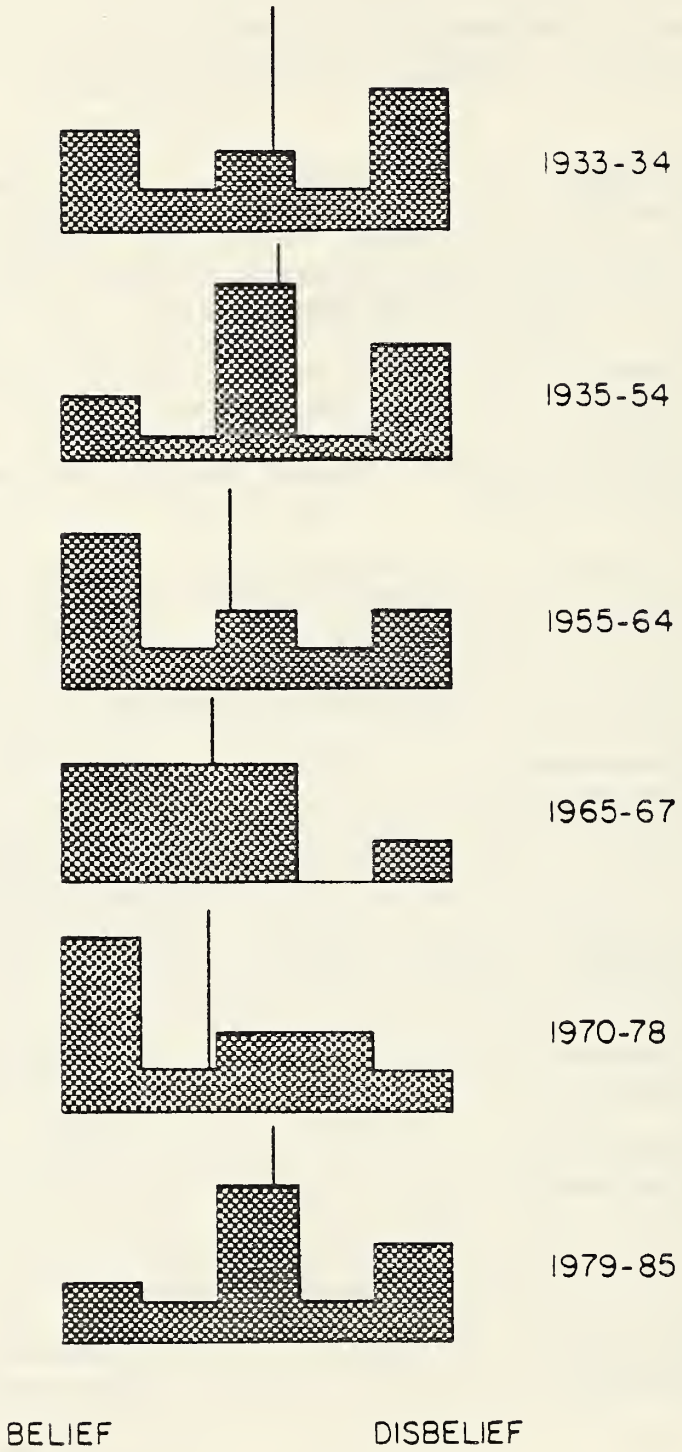
1933-34
1935-54
1955-64
1965-67
1970-78
1979-85
BELIEF
DISBELIEF

Figure 1

Changes of Attitudes in Magazines and Journals
1933-1985

Reading left to right:

Relative numbers of articles in each category

Outright belief

Tendency towards belief

Neutral

Tendency towards disbelief

Outright disbelief

The vertical line represents the weighted average of the opinions expressed

See text, pages 80-81.

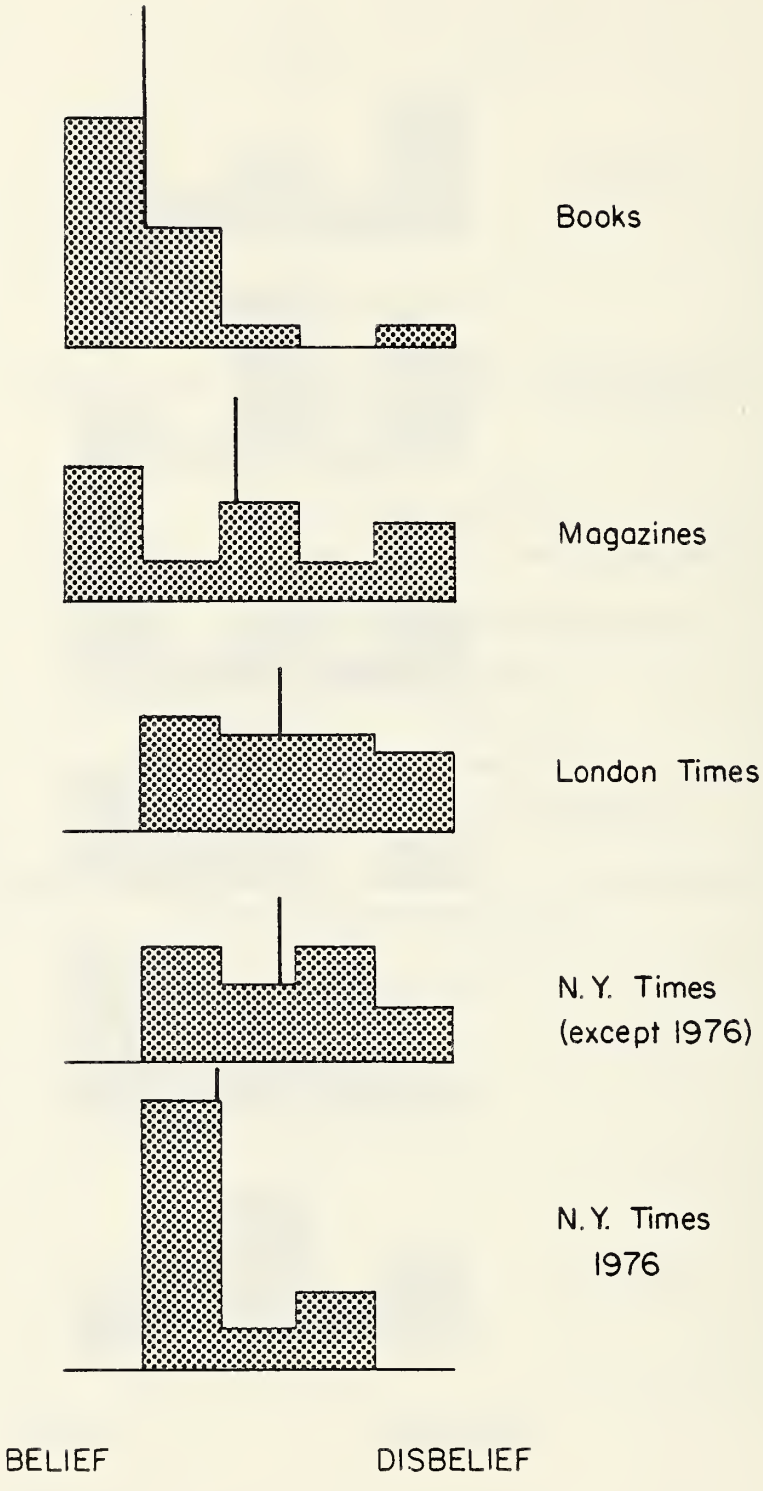
Books
Magazines
London Times
N.Y. Times
(except 1976)
N.Y. Times
1976
BELIEF
DISBELIEF

Figure 2

Different Attitudes Expressed in Books, Magazines and Newspapers

Reading left to right:

Relative numbers of items in each category

Outright belief

Tendency towards belief

Neutral

Tendency towards disbelief

Outright disbelief

The vertical line represents the weighted average of the opinions expressed

See text, pages 80-81.

also because newspapers concentrate on current events and do not usually provide much in the way of background. This, of course, is partly because reporters usually have little time to spend on research for any given story. On normal matters, journalists can get a quick and reliable briefing from relevant experts and from reference works; but on matters such as the Loch Ness Monster there are no publicly acknowledged experts, and the encyclopedias are no use at all (Bauer, 1987) - they barely mention the matter and give no citations for further reading.

Journals

While the attitude taken by newspapers has not changed much since 1934, that conveyed in articles in magazines and journals has, quite significantly. In Figure 1, the attitude conveyed by a given article is assigned to one of five categories: definite belief that Nessie is real, a tendency towards belief, neutrality, a tendency towards disbelief, or outright disbelief; and the charts reflect the relative numbers of articles in these categories. (The vertical line represents the weighted average of the opinions expressed). In 1933-34, average opinion tended towards disbelief, strong disbelief was more common than strong belief, and both were more common than neutrality; in other words, controversy was high and opinion was strongly polarized. During the next twenty years the average opinion didn't change, but neutrality gained at the expense of both extreme attitudes, possibly because not much was being reported from Loch Ness so there was less occasion for public argument and consequent polarization. From the mid-1950s through the 1970s, average opinion moved towards belief, probably because of several factors: Dr. Constance Whyte's writing in the 1950s, the Dinsdale film of 1960 and subsequent founding of the L.N.I.B., Professor Roy Mackal's enlisting of support from Field Enterprises and a lot of favourable publicity associated with that, and the underwater photographs obtained by Dr. Robert Rines's teams. Since the late 1970s, however, the expressed attitude has reverted towards disbelief, with a degree of polarization quite like that of 1935-to-1954, perhaps because, as in those earlier quiet years, nothing sufficiently dramatic actually happened at Loch Ness.

Different Attitudes

Different attitudes are conveyed in books, in magazines, and in newspapers (Figure 2). Most of the books are written by believers, of course, as is the case with anomalous phenomena generally. The attitudes expressed in magazines are much more

polarized; and those of the national newspapers much more disbelieving. Another example of the influence of editorial policy, as opposed to actual events, is illustrated by the coverage given to Loch Ness by the *New York Times*. Generally as disbelieving as the *Times* of London, and giving only a little more space than the latter in most years, in 1976 the *New York Times* published about twice as many articles about Loch Ness as it had during the entire previous forty years; and the tone of those articles was markedly positive, whereas over the years it has been somewhat disbelieving. What was different in 1976? Nothing substantively to do with knowledge about Nessie, only that the *New York Times* sponsored the work of the Academy of Applied Science in that year.

Different Coverage

What can one make of the changing frequency of writing about Loch Ness over the years (Table 4)? The increase from the mid-1950s into the mid-1970s, and subsequent decline, parallels the change in conveyed attitude, from polarized and disbelieving towards belief and then back again; and so the same explanation can be offered, the influence of Constance Whyte and those others who engaged in the search from about 1960 onwards. It is salutary always to keep in mind, however, that such suggested explanations can only be tentative unless some independent support for them can be found, because unsuspected alternative explanations might be available. In the present instance, having evolved the explanation just given, I was a little abashed to read a survey of writings about anomalous phenomena in general (Dutch, 1986), because it turns out that the number of books published about such matters as UFOs, Bigfoot, Atlantis, and psychic phenomena also showed a marked increase from the 1950s into the 1970s and a subsequent decline (Figure 3). So there was a greater public receptivity to such things, and an environment more conducive to such things being published, during those years; consequently one cannot be sure to what extent the increased volume of publication about Loch Ness must be ascribed to that general factor, rather than to factors specific to Loch Ness. It would, of course, fit Westrum's findings if events at Loch Ness had relatively little to do with it, and that the chief factor was public receptivity - editors more likely to decide to publish, and eye-witnesses less reluctant to report.

Accuracy

As well as the amount published and the attitudes conveyed, of equal interest is the accuracy or reliability of what is published. Here I was pleasantly surprised to find that

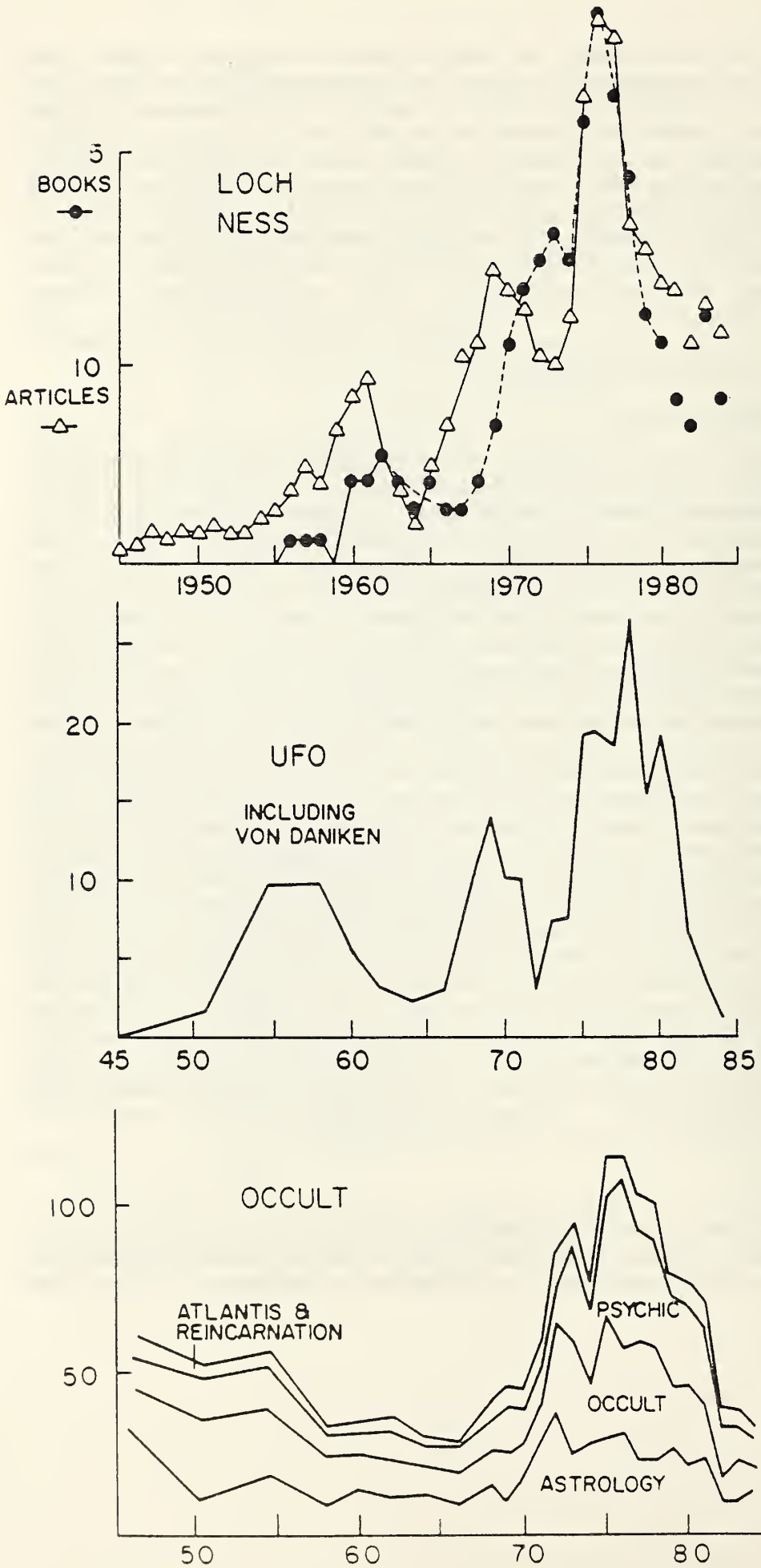
5
BOOKS
10
ARTICLES
LOCH
NESS
1950
1960
1970
1980
20
10
UFO
INCLUDING
VON DANIKEN
45
50
60
70
80
85
100
50
OCCULT
ATLANTIS &
REINCARNATION
PSYCHIC
OCCULT
ASTROLOGY
50
60
70
80

Figure 3

Books and Articles Published on Anomalies
and Psychic Phenomena

1945-date

The number of books and articles published on Loch Ness, UFOs, Bigfoot, Atlantis, and psychic phenomena showed a marked increase from the 1950s into the 1970s and then a subsequent decline.

See text, page 81.

Table 4

Loch Ness in Books, Magazines, and Newspapers

	Books†	Magazine Articles	*Times* (London)
1933-34	(5)	(230)	(220)
1935-39	-	8	21*
1940-44	-	2	1
1945-49	-	5	-
1950-54	-	11	3
1955-59	1	23	1
1960-64	2	48	11
1965-69	2	56	11
1970-74	5	75	12
1975-79	7	124	30**
1980-84	1	86	9
1985-86	(5)	(69)	(-)

† Serious books written for adults. Some serious books for children were also published: one in 1965-69, two in 1970-74, six in 1975-79, one in 1980-84. Fictional books about Nessie, mostly for children, also appeared: one in 1960-64, one in 1970-74, three in 1975-79, two in 1980-84, four during 1985-86. In addition, some booklets or pamphlets were published: three in 1934; one each in 1950-54, 1965-69, 1970-74, 1975-79, and two in 1980-84. In all cases, only the first edition of a work is counted and not subsequent editions. (Figures in parentheses are what the rate would be for a five-year period, for ready comparison with the other numbers).

* 19 of these were in 1938, about Munro's proposed search.

** 18 of these were about the aborted symposium of 1975.

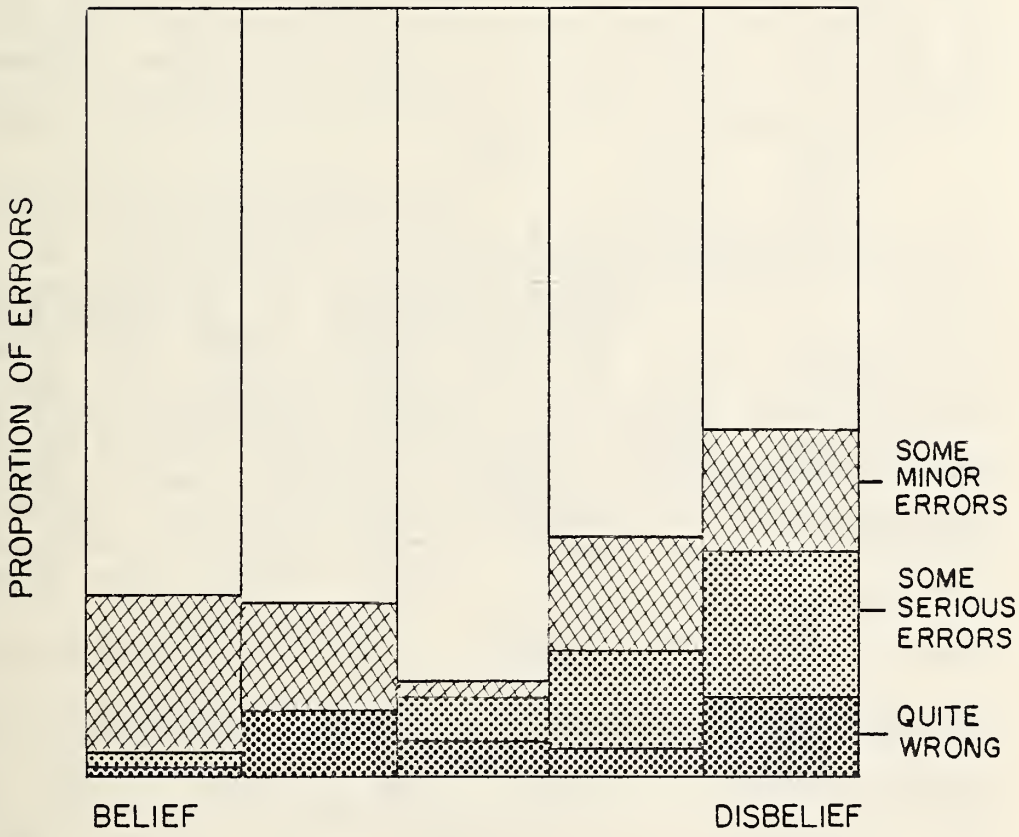

Figure 4

Errors in Published Writings about Loch Ness

Reading left to right: belief, towards belief, neutral, towards disbelief, disbelief. The frequency of moderate or serious errors increases markedly from articles expressing belief to those expressing disbelief.

See text, pages 81 and 87.

Table 5

Articles Expressing Disbelief and Jocularity

	Entirely serious	Slightly jocular	Jocular	Entirely jocular	Average score
('Score')	(0)	(0.5)	(1)	(2)	
Articles expressing:					
Strong belief	96%	2%	1%	1%	0.03
Leaning to belief	91%	6%	3%	-	0.06
Neutral	81%	12%	6%	1%	0.14
Leaning to disbelief	48%	48%	4%	-	0.29
Strong disbelief	63%	8%	19%	10%	0.42

errors were most marked in those writings which expressed the most disbelieving attitude (Figure 4). The frequency of moderate or serious errors increases markedly from articles expressing belief to those expressing disbelief, reaching a high of more than one article in every three among the thoroughly disbelieving. That, of course, is only to be expected: people who don't take the possible existence of Nessies seriously, are unlikely to take the time to become properly familiar with the literature on the subject.

Disbelief and Jocular Attitude

I was not at all surprised to find a positive correlation between disbelief and a jocular attitude (Table 5): only a small percentage of the strongly believing articles venture humour about Nessie, whereas about 40% of the disbelievers' pieces are jocular to some extent. It seems that the most confirmed disbelievers, however, are somewhat less likely to indulge in humour than those who are temperate in their refusal to believe; and I would like to explain this by the well-known fact that true disbelievers are quite like true believers on any given matter, for instance in quite lacking a sense of humour about it (Hoffer, 1951).

Type of Journal

An examination of the types of magazines and journals which have published about Loch Ness is also of interest (Table 6). I had not expected to find that as much as 30% of the writing has been in respectable journals of science or popular science, such as *Nature, Wildlife* or *National Geographic*. The largest amount has been published in mass-circulation magazines such as *Time,* and only about one quarter of all the articles are in magazines which specialize in anomalous matters. This is a picture quite different from most other anomalies, certainly those demonstrably in the area of pseudo-science, such as astrology. The attitudes expressed in these different genres are as one would expect (Figure 5): the most believing in the specialist anomaly magazines, and the least believing in the journals of science and popular science. I had not, however, expected to find the Loch Ness articles in the latter journals to be, as they are, on the average neutral, and I was gratified to find the largest degree of neutrality expressed in the scientific journals, in fact almost a consensus to sit on the fence, compared with the high degree of polarization evident in magazines of popular science and in general-interest or mass-circulation periodicals. The literature about Loch Ness, from some of these points of view, is more like the literature

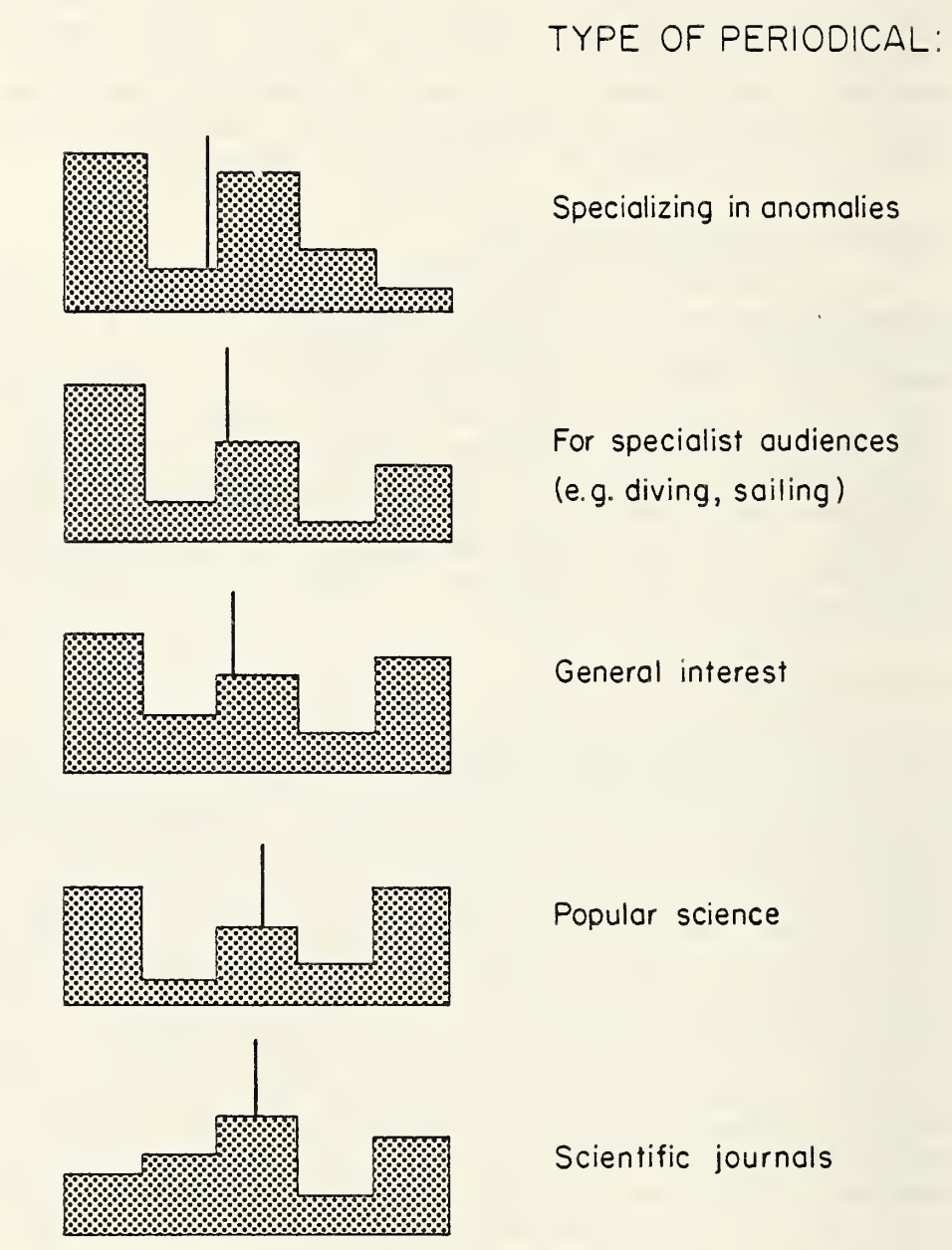
TYPE OF PERIODICAL:
Specializing in anomalies
For specialist audiences
(e.g. diving, sailing)
General interest
Popular science
Scientific journals
BELIEF
DISBELIEF

Figure 5

Attitudes Expressed in Different Types of Publication

Reading left to right:

Relative numbers of items in each category

Outright belief

Tendency towards belief

Neutral

Tendency towards disbelief

Outright disbelief

The vertical line represents the weighted average of the opinions expressed

See text, page 87.

Table 6

Articles in Magazines of Different Types
(Percentages, rounded to nearest 5%)

	General interest	Popular science	Scientific journals	Small circulation	Anomalies
1933-34	75	5	10	10	-
1935-54	55	5	-	5	35
1955-64	45	30	-	5	20
1965-69	15	20	10	15	45
1970-78	25	15	15	20	25
1979-83	15	50	5	15	20
Overall 1933-1983	35%	20%	10%	15%	25%

The periods of time were chosen to correspond to marked changes in expressed attitude. See Figure 1 , and also Table 5 in Bauer (1987).

of a subject of possible validity than that of a thoroughly discredited topic.

Future Perception

As I was making notes for this talk, I found myself wanting to say something about the future. Does this analysis signify anything for the future of public perception of the Loch Ness monster? What must the hunters do if they wish to be successful in public persuasion as well as in the hunt itself? One might note the extreme conservatism of editorial policies, and therefore not expect much to change too quickly. One might cultivate good relations with particularly well-informed journalists, and with the editors of those papers which have a relatively open approach to Loch Ness, which at present seems to mean local and regional rather than national papers. One might note that, in general, we appear to be in a period of declining interest and of decreasing willingness to believe in matters of this sort, which indicates that favourable change in public perception may be difficult or impossible to achieve in the near future almost irrespective of any actual results of the search. Admittedly, all this adds little to what most hunters have long recognized, that the reality of Nessies will be widely accepted only on the basis of a captured living specimen, a carcase, or an incredibly clear close-up moving film.

From one point of view, however, those concerned with Nessies can look to the future with complete confidence, for the hunt has significance which goes far beyond the question of the existence of the creatures; it goes to the heart of our attitude towards seeking knowledge about the world. As Tim Dinsdale put is long ago (Dinsdale, 1966: 197-198; 1972: 197-198), the Monster in itself is not of any particular importance; what is important is the attitude towards truth taken in what we call a scientific era.

Conclusion

History, it seems to me, indicates that the distribution of power in human societies has been changing for some time - in principle if not always in practice, and of course not continuously or particularly steadily - from avowedly and unashamedly centralized and authoritarian, towards decentralized and diffused (democratic, if you will), as far as social, political and economic matters are concerned. And now most recently, I think we are seeing a similar change in the matter of accepted knowledge. Religious leaders lost their authority in, or their monopoly on, accredited knowledge some

time ago, and that authority was thereupon assumed by science and its spokesmen. In recent decades there has been a certain restiveness on that score, and science is being increasingly pushed to justify its authority, since some of the corollaries of that authority seem unpalatable to various people. This movement is exemplified, I should like to suggest, by issues like the Loch Ness Monster, because these issues are such clear examples of interesting questions about which science does not have good answers. And so the scientific community is pushed to make itself publicly comprehensible; which I take to be a good thing.

Knowledge progresses not so much as we find answers, but rather as we find new sorts of questions to ask. The Loch Ness phenomenon has caused a number of people to find new questions to ask, not only about matters biological or technical but also about matters human and social; and so, irrespective of whether Nessies exist or can be proven to exist, the search contributes to the progress of human understanding.

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THE WILSON NESSIE PHOTOGRAPH: A SIZE DETERMINATION BASED ON PHYSICAL PRINCIPLES

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Introduction

The object which appears in the well-known photograph taken in 1934 by a London surgeon, Lt. Col. R. Kenneth Wilson F.R.C.S. (Figure 1) has commonly been identified with Nessie, the Loch Ness Monster. Its likeness has appeared on souvenirs and logos, and has entered the public perception as the archetypal form of Nessie. Over the years, however, there has arisen much speculation as to the precise nature of what appears in the photograph.

It is not our intention to contribute to the debate on the photograph's authenticity, or to add to the remarkable list of alternative explanations already proposed: Otter, Killer Whale, diving bird, emerging tree-trunk, or swimming Elephant, amongst others. Readers may review the critical history of the Wilson photograph by consulting any of the standard works on the topic (e.g. Dinsdale 1961, Burton 1961, Holiday 1968, Costello 1974, Witchell 1974, Mackal 1976, Power and Johnson 1979, Binns 1983, Campbell 1986, Bauer 1986). The point being addressed here, which has long been recognized as a major source of uncertainty, is the absence of identifiable features capable of providing a scale for Nessie in the photograph. It has been argued that it matters a great deal whether the object is only a few centimetres long, and thus possibly part of a small familiar animal, or perhaps a couple of metres long, and thus too large to be so easily explained away.

Until the early 1980s, only cropped and enlarged versions of the photograph (as shown in Figure 1) have been available for analysis. Holiday (1968) attempted a calculation of the object's dimensions based on a series of assumptions which he felt were too numerous and shaky to inspire much confidence in the result: about 6 ft (1.8 m) for the neck portion emerging above the water level. Recently, Campbell (1984) discovered an uncropped print at Associated Newspapers (Figure 2), and he then performed a more direct analysis, which yielded an estimate of 0.7 m for the same dimension. More recently, Mr. Alastair Boyd obtained a print of the uncropped version published in the 28th April 1934 issue of *The Illustrated*

Figure 1. The classic photograph of Nessie, a cropped and enlarged version of the photograph taken by Lt. Col. Kenneth Wilson at Loch Ness in April 1934.

Figure 2

Figure 3

Figures 2 and 3.

Original, uncropped prints of the Wilson photograph (see text), with opposite shore visible. Not retouched. Figure 3 gives the entire quarter-plate picture.

Note the secondary concentric wave pattern around Nessie; the ellipticity of this pattern has been used to calculate the viewing angle.

London News (Figure 3), which he kindly provided to the authors. Our analysis is therefore complementary to that of Campbell. It uses the wind waves visible in great number in the uncropped positive of the Wilson photograph to deduce a scale for Nessie. The method is similar in principle to that used in scaling Champ in the Mansi photograph of the Lake Champlain Monster (LeBlond 1982).

Method

A wind-swept sea consists of a confused superposition of waves of a range of lengths and amplitudes, travelling roughly in the direction of the wind (Kinsman 1965). A background of wind waves is thus generally too irregular to be used as a simple graduated scale against which to measure an object at the sea surface; it may be used as a scale, but only in a rather more subtle way.

The distribution of wave energy amongst wavelengths (the energy spectrum) has a peak at a wavelength which corresponds closely to the 'significant' wavelength which a trained observer would deduce from visual observation. For some angles of view, especially when the waves are seen from the side, as in the Mansi photograph (LeBlond 1982), the significant wavelength is easily determined. This is not the case for the Wilson photograph (also known as 'the surgeon's photograph'), where the wave field is seen nearly head-on. Although we shall attempt a simple scale comparison with what appears to be a single wavelength near Nessie, we shall also use a more objective method based on a quantitative analysis of the wave field.

The distribution of energy amongst waves of different lengths is usually determined by sampling over a large number of waves, either in time, at a fixed point, or over an area broad enough to average out the irregularities of the waves. In order to sample the waves seen in Figures 2 and 3, the image was first digitized into an array of 512 x 512 pixels of brightness levels ranging from white to black over 256 steps of a grey scale. The brightness level depends on the intensity of reflected sunlight, and hence on wave slope, rather than height. This is an important point in interpreting our results. Brightness levels were sampled along fourteen parallel slices running in the direction of wave propagation, i.e., perpendicular to the wave crests. Figure 4 shows an example of brightness variation along one of the slices. The numbers of crossings by the brightness curve of its average value were counted over segments of 50 pixels along a slice and averaged over all slices. These numbers appear in Table 1. They will be

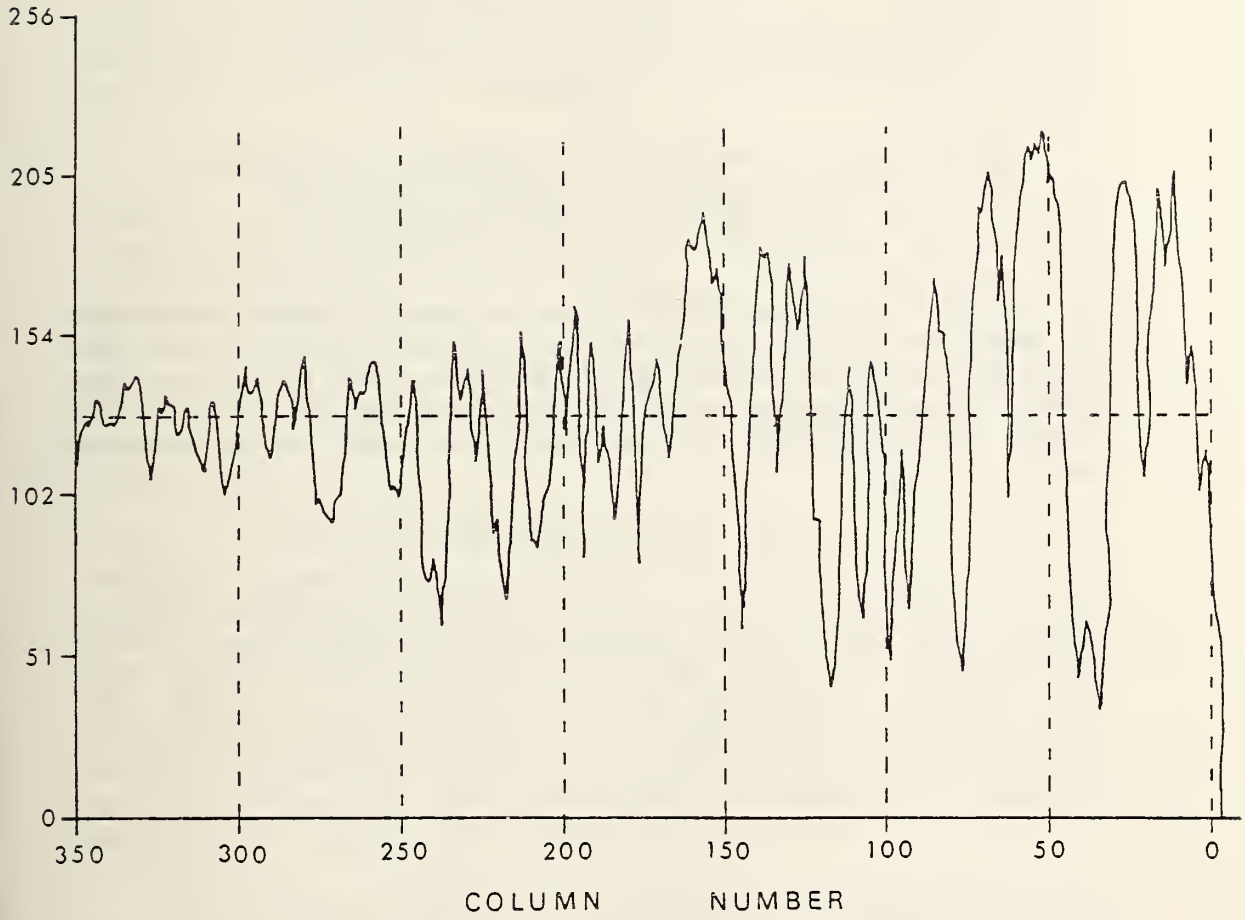

Figure 4

Brightness variation along a slice of Figures 2/3 near Nessie (which is near column 65).

Table 1

Zero-Crossing Statistics of Brightness Fluctuations in the Image Plane, based on 14 Slices such as that shown in Figure 4

In the following Table, n is the number of zero crossings in each Δy = 50 pixel interval in the direction of wave propagation (20° from the left of the image vertical), y is the middle pixel value for each interval from the beginning of the slice, at the bottom of the image, y_m = 350 is the maximum number of pixels in a slice.

y	n	y/y_m	$n(1 - y/y_m)^2$
25	4.60	0.07	4.00
75	6.50	0.21	4.05
125	9.40	0.36	3.90
175	10.30	0.50	2.60
225	10.50	0.64	1.36

used to determine the average wavelength L on the basis of two zero-crossings per wavelength.

Since the waves are not seen directly from above, their apparent spacing changes with position in the image; the nearest waves appear longer in Figures 2 and 3. With reference to Figure 5, we find that a segment Wx in the plane of the loch surface is related to a segment Wy of the picture plane through

$$\Delta x = \frac{\Delta y}{\sin \theta_o \, (1 - y/y_m)^2} \qquad (1)$$

where y is the distance from a reference point on the picture plane, y_m the maximum value of that distance, and θ_o the angle which the picture plane makes with the vertical. We assume that the wave field is statistically homogeneous over the part of the image in which we are interested, so that the compression of wavelengths with distance is entirely due to the angle of view. If there are n brightness zero-crossings over a chosen picture plane interval Δy, then $\Delta x = nL/2$, and from (1) we expect that

$$n(1 - y/y_m)^2 = 2\Delta y/(L \sin \theta_o) \qquad (2)$$

should be a constant over a range of values of y. Table 1 lists average zero-crossing counts over six $\Delta y = 50$ pixel intervals in the image plane and corresponding estimates of the left-hand side of (2). The angle θ_o is taken, as in Campbell (1984), from the apparent ellipticity of the secondary wave patterns concentric to Nessie as $\theta_o = 19°$. The number of pixels per average wavelength L of the brightness fluctuations may then be evaluated from (2). The dimensions of Nessie, in terms of numbers of pixels, may thus be expressed in terms of wavelengths.

The final step, of course, is to obtain an estimate of the actual physical dimension of a wavelength. The length of wind waves increases with wind speed, duration, and fetch; empirical results for growing waves are given by Carter (1982). For sufficiently long duration and fetch, waves stop growing and lengthening: the sea is said to be fully developed. Under such conditions, and we shall discuss whether they could have been achieved at the time, the wavelength L_m corresponding to the peak of the spectrum in deep water (deeper than a wavelength) is given (in meters) by

$$L_m = 0.83 \, U^2 \qquad (3)$$

where U is the wind speed at a height of 10 m above the water surface, in m/s. Since Loch Ness is long in terms of the fetch required to set up a fully developed sea at the low wind speeds considered (about 20 km), we shall remark only on the

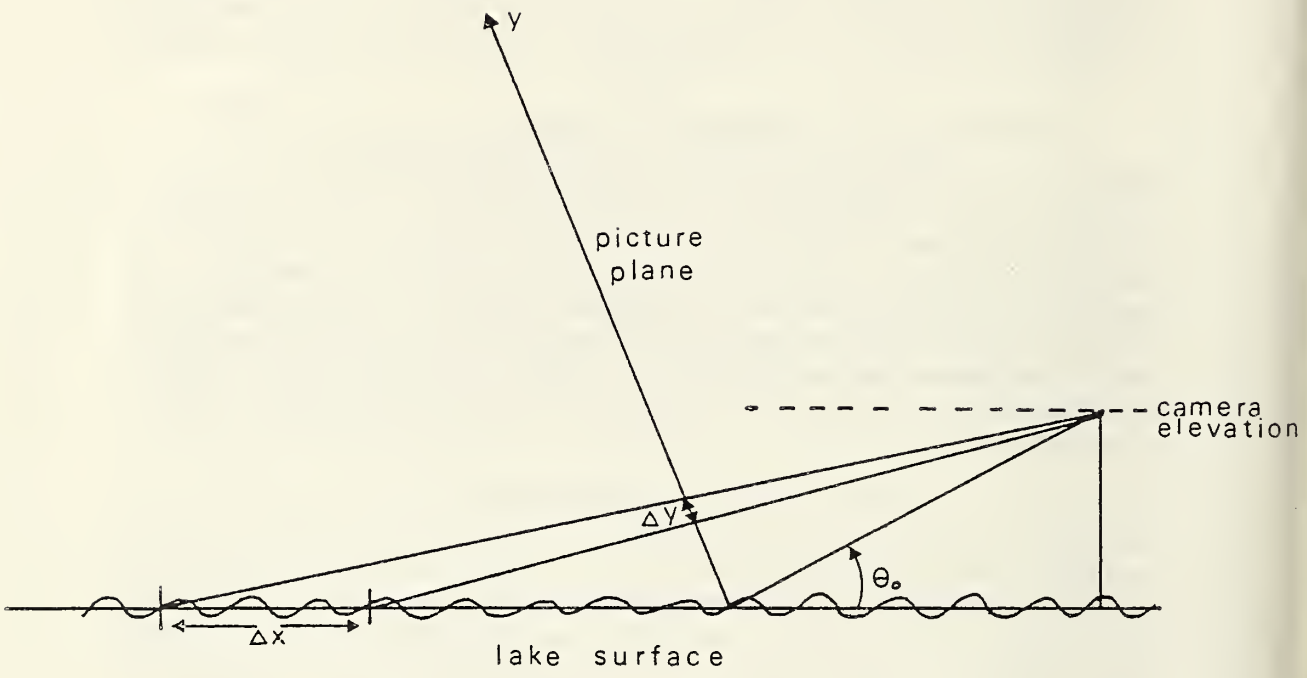

Figure 5

Geometrical relations between segments in the plane of the loch surface and the image plane. The viewing angle θ_0 is calculated from the ellipticity of the pattern in Figures 2/3.

possibility of the wind field being duration-limited. From Carter (1982: Appendix A) we find that for duration-limited waves

$$L_m = 0.45\ D^{0.86}\ U^{1.14} \qquad (4)$$

where D is the duration of the wind of speed U (in hours).

Wind information was obtained from the National Meteorological Library, Bracknell, Berkshire, for the presumed date on which the photograph was taken: 19th April 1934, at about 7.00 a.m. (cf. Campbell 1984, for a discussion of that date). On that morning, the nearest Scottish weather stations, at Dalwhinnie (56°56'N, 04°14'W) and Aberdeen, respectively reported calm conditions (no wind) and winds from the west-north-west at force 3 (3.5-5.0 m/s). Neither station is representative of conditions at the Loch. The former is located 23 miles south-east of Invermoriston, Loch Ness; the latter, on the shores of the North Sea, is about 90 miles east of Invermoriston. We may, however, take the weak wind conditions measured at the weather stations, together with the surface atmospheric pressure map issued on that morning, as indicative of weather conditions over most of Scotland.

More specific information at Loch Ness comes from the photograph itself. The appearance of the sea surface changes gradually as the wind speed increases in a manner formalized in the Beaufort Scale (Allen 1983). The critical point to note here is that there is not a single breaker visible in Figures 2/3. This observation limits the wind speed to force 2 (U = 2.5-3.0 m/s). This is consistent with observations by Monahan (1971) of whitecap coverage, as well as with the general meteorological conditions for that morning.

We now have in hand all the elements necessary to relate the apparent dimensions of Nessie in Figures 2/3 to those of the waves, and to obtain an estimate for the physical wavelength itself in terms of the wind speed. We shall discuss possible errors later.

Results

Let us first estimate the wavelength of the spectral peak from observed wind conditions. We shall assume that the wind was blowing from the north end of the Loch, as inferred from the photograph and from the general weather conditions, at a speed appropriate to Beaufort force 2 (U = 3.0 m/s). The presumed location of the photograph, 2-3 miles on the Inverness side of Invermoriston, gives an upwind fetch of about 20 km. From Carter (1982), a duration of six hours is required for the full development of a wind sea for that fetch and wind speed.

From (3), L_m = 7.5 m under those conditions. It is quite conceivable, however, and perhaps more likely in view of the frequent diurnal modulation of valley winds, that the wind might not have been blowing for six hours or more. Wilson's recollections, as quoted by Campbell (1984), are uninformative in this respect. For a shorter duration, D = 3 hr, (4) yields L_m = 4.0 m.

The other point to recall is that what is observed in Figures 2/3 is a distribution of wave slopes, not of wave amplitudes. The results just quoted for L_m are for wave amplitudes; the slope spectrum is obtained from the displacement spectrum by dividing by the square of the wavelength; its peak occurs at shorter wavelengths. The J.O.N.S.W.A.P. spectrum appropriate for growing seas is quite steep, and a modicum of algebra shows that the length L of the peak of the slope spectrum is very near L_m ($L = 0.95\ L_m$). The difference is too small to be of concern to us in the present context.

In view of the above, and on the basis of the first author's personal experience with a similar sea state on Loch Ness, we shall adopt L = 4.0 m as the wavelength of the brightness fluctuations in Figures 2/3. Readers will, of course, be aware of the subjective aspect of this choice, and may wish to scale the results up to L = 7.5 m, which would correspond to the absolute upper limit for the wind force and sea development.

It is useful at first to short-circuit the painstaking pixel counting process leading to (2), and to perform a direct, if rather subjective, visual comparison of Nessie with the nearest wave. In Figures 2/3, we judge that Nessie occupies about 70% of the vertical distance in the image plane between the nearest dark bands on either side of it. A correction by the factor ($1/\cos[20°] = 1.06$), to take into account the angle of propagation of the waves, brings that ratio up to 74%. Taking the viewing angle into account, as shown in Figure 6, we have $h/x = \tan(19°)$. With x = 0.74 L, h = 1.06 m (3.5 ft). This estimate is surprisingly close to that originally given by Wilson, who reported "I saw a long neck, about three feet out of the water, and a head which looked small" (Anon. 1934).

Results of the more objective wavelength estimation based on zero-crossings are included in Table 1. The last column gives estimates of the right-hand side of (2) for a sequence of bands of 50 pixels in the image plane; these numbers should all be the same for purely geometrical distortion. The values fall

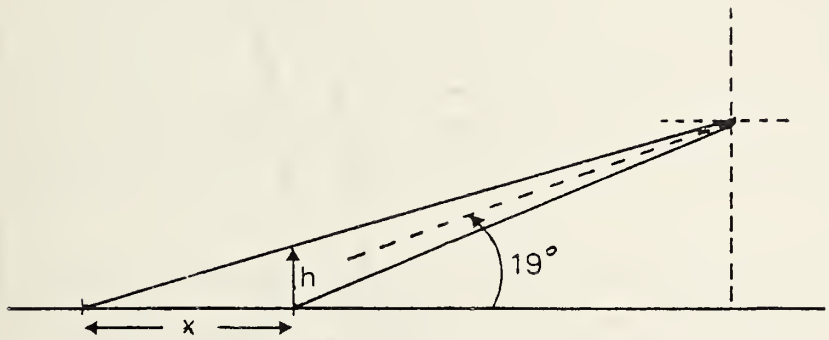

Figure 6

The geometry pertinent to calculation of Nessie dimensions from comparison with wavelength

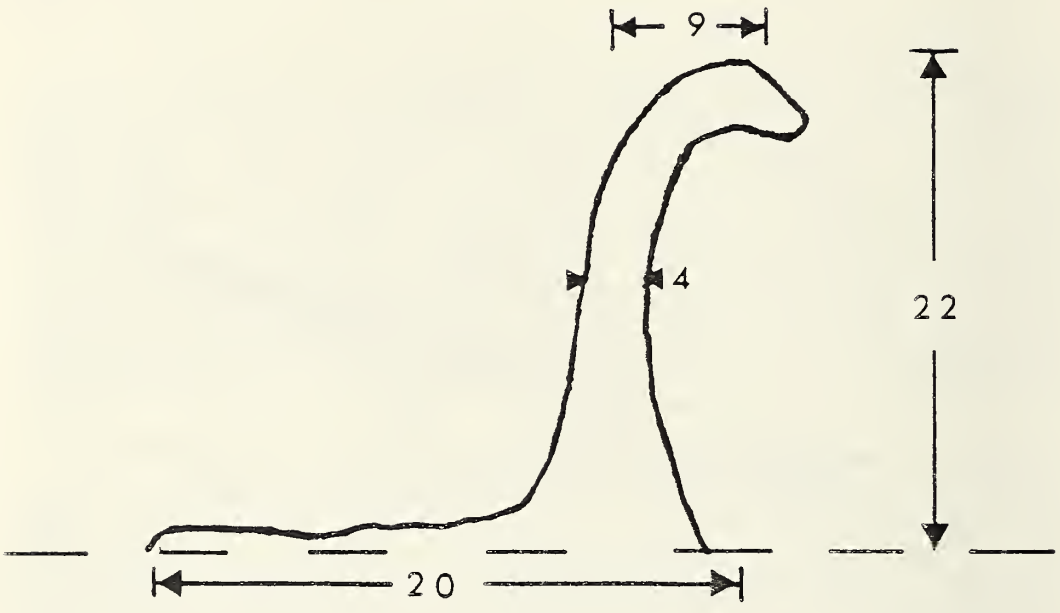

Figure 7

Pixel dimensions of Nessie in the image plane, based on a 512 x 512 digitization of Figures 2/3. Drawing not necessarily accurate.

off in the fourth and fifth bands, at the top of the image, where digitization leads to serious loss of resolution. We are satisfied, however, that the wave field seen in the first three bands is homogeneous, and that the value 4.0 may be used for the right-hand side of (2). We then calculate that

$$L = \frac{y}{2 \sin(19°)} = 77 \text{ pixels}$$

in the plane of the loch surface. In the image plane, a wavelength then covers L sin(19°) = 25 pixels. The dimensions of Nessie in terms of pixels in the image plane are shown in Figure 7. Instead of 70% of a wavelength, as in the above 'simple' analysis, we now have 22/25 = 88% (there is no need to apply the 1/cos[20°] correction since the wavelength is already calculated in the direction of wave motion). Using the same viewing angle as above, the geometry of Figure 6 now gives h = 0.88 L tan(19°) = 1.21 m (4 ft).

Discussion

Our analysis yields a value of 1.2 m (4 ft) for the height of Nessie's neck as it appears in the photograph. Other possible (subsurface) dimensions may be estimated in proportion from Figure 7. We have discussed and presented all assumptions made in obtaining this result, so that readers may be aware of its limitations. The most important assumption concerns the duration of the wind before the photograph was taken. Shorter (1 hr) or longer (6 hr) assumed durations change the wavelength of wind waves up or down by a factor of two, with a similar effect on Nessie's size estimate.

The results are too inconclusive to draw specific biological conclusions, although perhaps the bird hypothesis can be discarded. From a general point of view, we find that the object seen in Figures 2/3 is of a dimension which certainly warrants all the interest which it has received and the mystery which surrounds it.

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